Section N

No 814

SEVENTEENTH ANNUAL REPORT

OF THE

BUREAU OF MINES, 1908.

(VOL. XVII.)

CONTENTS

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ILLUSTRATIONS

MAPS.

ERRATA.

Page 7, column 1; 1907 should read 1906.
Page 7, column 3; $13,053 should read $213,053.
Page 21, column 4, last line; 1,117 should read 1,417.
Page 29, sixth line from bottom; $756,174 should read $746,499.

LETTER OF TRANSMISSION.

To His Honor Sir William Mortimer Clark, &c., &c., &c.,
Lieutenant-Governor of the Province of Ontario.

Sir,—I have the honor to transmit herewith for presentation to the Legislative Assembly the Seventeenth Annual Report of the Bureau of Mines.

I have the honor to be, Sir,
Your obedient servant,

F. Cochrane,
Minister of Lands, Forests and Mines.

Department of Lands, Forests and Mines,
Toronto, 2nd April, 1908.

INTRODUCTORY LETTER

To the Honorable Frank Cochrane,
Minister of Lands, Forests and Mines.

Sir,—I beg to submit to you herewith for presentation to His Honor the Lieutenant-Governor the Seventeenth Annual Report of the Bureau of Mines.

The review of the mining industry for the year 1907 shows that substantial progress is being made in developing the mineral resources of the Province, the aggregate value of the output of mines and mineral works last year being $2,630,990 in excess of that for 1906, or upwards of $25,000,000 in all. As the value of the production in 1891 was about $4,700,000, and in 1898 $7,236,000, it is evident that mining is at least keeping pace with other staple industries in the general progress of the country. The silver mines of Cobalt are largely helping in this work of development; in 1907 their product had a value almost twice as great as that of the placer gold deposits of the Yukon. Cobalt has, in fact, proven itself to be one of the most important mineral fields discovered in America, or in fact in the world, during the past forty years.

The Summer Mining Classes for the benefit of prospectors and working miners were last year conducted by Messrs. E. G. R. Ardagh and Wyatt Malcolm, who briefly report on the results of their labors.

The Inspector of Mines, Mr. E. T. Corkill, reports on the Mines of Ontario, giving details as to the work carried on in the several mining districts into which the Province naturally divides itself, and at the operating mines and plants. An exception is made of the silver mines of Cobalt, which are fully dealt with in Part II of the Sixteenth Report. An important part of the Inspector's duties is to see that proper precautions as required by law are taken to protect the lives and safety of mining employees, and attention is directed to Mr. Corkill's remarks on the subject of mining accidents, and the necessity for vigilance and care in the handling of explosives.

One of the Bureau's functions is to ascertain and study the geology of the outlying part of the Province, very much of which is not yet accurately known, and accordingly Mr. Arthur L. Parsons of Toronto University was attached as geologist to a surveying party sent out under the leadership of Mr. Alexander Niven, O.L.S., to define the boundary between the districts of Algoma and Thunder Bay. Mr. Parson's report on the geology of the Thunder Bay-Algoma Boundary will be found in the present volume. While it does not reveal the existence of promising fields for mineral prospectors, the possibility of their occurrence is by no means precluded, and the account will be read with interest as descriptive of a region concerning which very little has hitherto been known.

Dr. A. P. Coleman and Mr. E. S. Moore continued in 1907 the explorations begun the previous year east of lake Nipigon, their chief object being to examine and map the outcrops of Iron formation known to exist in that region. Their respective reports on the Iron Ranges East of Lake Nipigon are accompanied by a geological map showing the territory examined during the two years, and by a smaller sketch map of the ground traversed by Mr. Moore separately.

The Iron and Steel Industry of Ontario is made the subject of a special report by Mr. George C. Mackenzie, whose technical attainments and experience well qualified him for the task. Mr. Mackenzie deals with all sides of the subject,—ore supplies, blast furnace methods, costs, etc.,—and describes all the existing steel and iron making

plants in Ontario, accompanying his descriptions and report generally with illustrations and diagrams. Mr. Mckenzie's account of what is being done elsewhere in the preparation of low grade magnetic ore for use in the blast furnace has special interest for this Province, where many deposits of such ore exist. There are problems in the magnetic concentration of our silicious or impure magnetites remaining to be studied, and it is probable Mr. Mackenzie may further pursue the subject on behalf of the Bureau.

The publications of the Bureau of Mines now comprise seventeen Annual Reports, beginning with the year 1891, and a few bulletins on special subjects. Each of these Reports contains its own index, but the need of a General Index permitting ready access to all the information given in all the Reports on any one subject has been found very urgent. Many of the Bureau's annual volumes, both of earlier and recent years, are out of print, but sets of the Reports have been placed in a number of public, university and technical college libraries, not only in Canada, but also in the United States and Great Britain, where they can be consulted. Mr. Frank Nicolas of Ottawa, who recently completed an Index of the Reports of the Geological Survey of Canada from 1885 to 1906, has been commissioned to prepare a General Index of the Bureau's publications, which will also include the Report of the Royal Commission on the Mineral Resources of Ontario (1890). The work is well advanced, and it is thought may be ready for distribution about the end of 1908 or beginning of 1909.

I have the honor to be, Sir,

Your obedient servant,

THOS. W. GIBSON,
Deputy Minister of Mines.

OFFICE OF THE BUREAU OF MINES,
TORONTO, 31st March, 1908.

REPORT OF THE BUREAU OF MINES 1908

VOL XVII

Statistical Review

By Thos. W. Gibson, Deputy Minister of Mines

In 1907 the mines and mineral works of Ontario yielded minerals and mineral products having an aggregate value in the form produced of $25,019.373, as compared with $22,388,383 in 1906, an increase of about 12 per cent. This is the largest output yet recorded. A period of marked growth in the mining industry of the Province set in about three years ago, and that the impetus has not spent its force is seen from the following figures showing the value of the mineral production during each of the last four years:

Year.	Value mineral production	Increase over previous year.
	$	Per cent.
1904.............	11,572,647	......
1905...............	17,854,295	54
1906..............	22,388,383	25
1907...............	25,019,373	12

The increase in 1907 over 1904 was no less than 116 per cent. To some extent the advance in value is owing to the higher prices for mineral products which have ruled during the last few years, but much the larger part is due to an increase in production in the characteristic minerals of the Province, viz., nickel, copper, silver and petroleum. To these should be added pig iron and Portland cement.

The following table gives a summary of the mineral production for the year 1907, together with the number of employees in the various branches of the industry and the wages paid them.

Table I.—Mineral Production of Ontario in 1907

Product.	Quantity.	Value.	Employees.	Wages.
Metallic:		$	No.	$
Gold..ounces	3,810	66,399	160	125,537
Silver .... "	10,028,259	6,157,871	2,038	1,532,067
Cobalt ....tons	739	92,751		
Nickel .... "	10,972	2,271,616	1,821	1,381,027
Copper .... "	7,303	1,015,511		
Iron Ore .... "	205,295	482,532	276	192,063
Pig Iron .... "	286,216	4,716,857	1,242 (a)	808,681 (a)
	....	14,833,537	5,540	4,042,375
Less value Ontario iron ore (120,177 tons) smelted into pig iron....................	....	282 702	....	....
Net metallic production	....	14,550,835	5,540	4,042,375

(a) Includes steel-making.

Table I.—Continued

Product.	Quantity.	Value.	Employees.	Wages.
Non-metallic :		$	No.	$
Arsenic ....tons	2,958	40,104	(b)	(b)
Brick, common ....No.	273,882,000	2,109,978	2,850	1,015,000
Tile, drain .... "	15,578,000	250,122		
Brick, pressed .... "	69,763,423	648,683	508	284,881
" paving .... "	3,732,220	73,270		
Building and crushed stone....	....	675,000	1,100	480,000
Calcium carbide ....tons	2,667	173,763	63	37,613
Cement, Portland....bbl,	1,853,692	2,777,478	1,237	699,464
" natural rock .... "	7,239	5,097	22	2,029
Corundum ....tons	2,683	242,603	247	168,333
Feldspar .... "	12,328	30,375	71	23,359
Graphite .... "	2,000	20,000	20	15,000
Gypsum .... "	10,186	19,652	18	14,370
Iron pyrites .... "	15,755	51,842	137	75,365
Lime ....bush.	2,650,000	418,700	415	155,000
Mica ....tons	456	82,929	158	63,450
Natural gas....	....	746,499	191	110,832
Peat fuel....tons	200	1,040	6	1,500
Petroleum ....Imp. gal.	27,621,851	1,049 631 (c)	435(d)	265,316(d)
Pottery....	....	54,585	55	20,220
Quartz....tons	56,585	124,148	101	52,400
Salt .... "	62,806	432,936	194	85,935
Sewer pipe	....	435,088	232	132,884
Talc ....tons	1,870	5,010	13	1,869
Non-metallic production....	....	10,468,538	8,073	3,704,820
Add net metallic "	....	14,550,835	5,540	4,042,375
Totals	....	25,019,373	13,613	7,747,195
Totals for 1906....	....	22,388,383	12,551	6,048,328

(b) Included in Silver and Cobalt. (c) Value crude product, exclusive of Dominion Government bounty.
(d) Petroleum refining works only.

The value of the net metallic production in 1906 was $13,353,080, and in 1907 it was $14,550,835, a gain of $1,197,755, or 9 per cent. The products in the non-metallic list were valued in 1906 at $9,035,303, and in 1907 at $10,468,538, an increase of $1,433,235, or about 16 per cent. The proportional gain was thus greater in the non-metallic than in the metallic products, but the contribution of the latter to the total was considerably more than that of the former, being 58 per cent. of the whole, as against 42 per cent. for the non-metallic substances.

The following table shows the increase or decrease in the value of the various products in 1907 as compared with 1906. From this it will be seen that of the metals, by much the largest gain was in silver, the value of which in 1907 was 66 per cent. greater than in the year before. A considerable falling off will be observed in nickel, the value of which declined 40 per cent. This is not to be attributed to any decrease in the output of the metal, the product in 1907 being in fact a few tons in excess of the year previous, but to a lower valuation placed by the producers on the nickel contents of their mattes. The non-metallic products show no decreases of moment; on the other hand, there are many increases, the principal of which, among manufactured articles, are pressed brick and Portland cement, and among crude substances, petroleum and natural gas.

Table II.—Comparative Value Mineral Production 1906 and 1907

Product.	1906.	1907.	Change.	
Metallic :	$	$		$
Gold....	66,193	66,399	I.	206
Silver....	3,689,286	6,157,871	I.	2,468,585
Cobalt....	80,704	92,751	I.	23,722
Nickel....	3,839,419	2,271,616	D.	1,567,803
Copper....	960,813	1,045,511	I.	84,698
Platinum metals....	5,652	....	D.	5,652
Lead....	93,500	....	D.	93,500
Iron ore....	301,032	482,532	I.	181,500
Pig iron	4,554,247	4,716,857	I.	162,610
Zinc ore	6,000	....	D.	6,000

Table II.—Continued

Product.	1907.	1907.	Change.	
Non-metallic :	$	$		$
Arsenic	15,858	40,101	I.	24,246
Brick, common	2,157,000	2,109,978	D.	47,022
Tile, drain	252,500	250,122	D.	2,378
Brick, pressed	337,795	648,683	I.	310,888
" paving	45,000	73,270	I.	28,270
Building and crushed stone	660,000	675,000	I.	15,000
Calcium carbide	162,780	173,763	I.	10,983
Cement, Portland	2,381,014	2,777,478	I.	396,464
" natural rock	6,000	5,097	D.	903
Corundum	262,448	242,608	D.	19,840
Feldspar	43,849	30,375	D.	13,474
Graphite	15,000	20 000	I.	5,000
Gypsum	6,605	19,652	I.	13,047
Iron pyrites	40,583	51,842	I.	11,259
Lime	496 785	418,700	D.	78,085
Mica	69,041	82,929	I.	13,888
Natural gas	533,446	746,499	I.	13,053
Peat fuel	900	1,040	I.	140
Petroleum	761,546	1,049,631	I.	288,085
Pottery	65,000	54,585	D.	10,415
Quartz	65,765	124,148	I.	58 383
Salt	367,738	432,936	I.	65,198
Sewer pipe	279,620	435,088	I.	155 468
Sodalite	6,000	....	D.	6,000
Talc	3,030	5,010	I.	1,980

In Table III is given a summary of the mineral production for the last five years, showing that the growth in value already mentioned has been general throughout the entire list of products, both metallic and non-metallic. It will also be observed that in 1905 the metalliferous branches of the mining industry for the first time surpassed the non-metalliferous in total value of output, and that although both are growing in importance, the former well maintains the lead.

Table III.—Mineral Production, 1903 to 1907

Product.	1903.	1904.	1905.	1906.	1907.
Metallic :	$	$	$	$	$
Gold	188,036	40,000	99,885	66,193	66,399
Silver	8,949	111,887	1,372,877	3,689,286	6,157,871
Platinum	....	10,452	28,116	5,652	....
Palladium	....	18,564			
Cobalt	....	36,620	100,000	80,704	92,751
Copper	716,726	297,126	688,993	960,813	1,045,511
Nickel	2,499,068	1,516,747	3 354,931	3,839,419	2,271,676
Iron ore	450,099	108,068	227,909	301,032	482,532
Pig iron	1,491,696	1,811,661	3,909,527	4,554,247	4,716,857
Steel	304,580	1,188,349	3,321,884	(a)	(a)
Lead ore	....	11,000	....	....	....
Pig lead	1,500	2,500	9,000	93,500	....
Molybdenite	1,275	....	....	....	....
Zinc ore	17,000	3,700	....	6,000	....
	5,678,929	5,321,677	13,113,125	13,596,846	14,823,537
Less value Ontario iron ore smelted into pig iron, and pig iron converted into steel	436,354	250,000	2,912,115	(b) 243,766	(b) 282,702
Net metallic production	5,242,575	4,906,667	10,201,010	13,353,080	14,550,835
Non-metallic :					
Actinolite	1,650	102	....	....	....
Arsenic	15,420	903	2,693	15,858	40,104
Brick, common	1,561,700	1,430,000	1,937,500	2,157,000	2,109,978
Brick, paving	45,288	55,450	54,000	45,000	73 270
Brick, pressed	218,550	226,750	234,000	337,795	648,683
Building and crushed stone	845,000	700,000	700,000	660,000	675,000
Carbide of calcium	144,000	152,295	156,755	162,780	173,763
Cement, natural rock	69,319	65 250	10,402	6,000	5,097
Cement, Portland	1,182,799	1,259,971	1,783,451	2,381,014	2,777,478
Corundum	87,600	150,645	152,464	262,448	242,608
Feldspar	20,046	21,966	29,968	43,849	30,375
Graphite	20,636	4,700	9,825	15,000	20,000
Gypsum	7,910	10,674	4 118	6 605	19 652

(a) Steel production not included. (b) Iron ore only.

Table III.—Continued

Product.	1903.	1904.	1905.	1906.	1907
Non-metallic:	$	$	$	$	$
Iron pyrites	21,693	43,716	21,885	40,583	51,842
Lime	520,000	406,800	424,700	496,785	418,700
Mica	102,205	37,847	50,446	69,041	82,929
Natural gas	196,535	253,524	316,476	533,446	746,499
Peat fuel	3,300	2,400	1,200	900	1,040
Petroleum products	1,586,674	901,437	898,545	761,546	(c) 1,049,631
Pottery	160,000	100,000	60,000	65,000	54,585
Quartz	....	....	....	65,765	124,148
Salt	388,097	362,621	356,783	367,738	432,936
Sewer pipe	199,971	283,000	225,835	279,620	435,088
Sodalite	....	....	....	6 000	....
Talc	2,625	2,919	2,240	3,030	5,010
Tile, drain	227,000	210,000	220,000	252,500	250,122
Total non-metallic production	7,628,018	6,665,970	7,653,286	9,035,303	10,468 538
Add metallic production	5,242,575	4,906,677	10,201,010	13,353,080	14,550,835
Total production	12,870,593	11,572,647	17,854,296	22,388,383	25,019,373

(c) Crude petroleum only.

Pursuing the practice followed in the two preceding annual Reports of the Bureau, and in order to admit of a fair comparison between the mineral production of Ontario and that of some of the other Provinces of the Dominion, as given in their official reports, or of Canada as a whole as given by the Geological Survey, the following table has been compiled, showing the value of the Ontario output on the basis of the values of the refined metals, instead of on that of their values at the pit's mouth, or in the product of the smelting furnaces. The latter is the system of computation which has been followed by the Bureau from the beginning, but as the result is to ascribe to the mineral yield of the Province a much lower value than it would have were the method of the Geological Survey or the other Provinces employed, it is only proper that the figures should also be presented on the "refined value" basis, so that mistaken conclusions should not be formed regarding the relative place of Ontario as a mineral-producing Province.

Table IV.—Mineral Production 1907 on "refined value" basis

Product.		Quantity.	Price.	Value.
Metallic:				$
Gold	oz.	3,810	$17.43 per oz.	66,399
Silver	"	10,028,259	65 327 cts. per oz.	6,551,608
Cobalt	tons.	739	$2 per lb. as Cobalt oxide. CoO.	3,600,538
Nickel	"	10,972	45 cts. per lb.	9,874,800
Copper	"	7,303	20 " "	2,921,200
Iron ore	"	205,295	$2 35 per ton	482,532
Pig iron	"	286,216	$16.48 "	4,716,857
				28,213,934
Non-metallic:				
Value per Table I				10,468,538
Gross production				38,682,472

It is not asserted that the foregoing table is an accurate presentation of the case. It is clearly inadmissible to value the cobalt contents of the silver ores of the Cobalt mines at their value as cobalt oxide, for the reason that the world's consumption of cobalt oxide per annum is much less than the quantity derivable from the ores of the Cobalt camp alone, and there can be no doubt that if the whole of the cobalt raised along with the silver of that district were thrown upon the market in the form of oxide the price would at once fall below its present level. For the cobalt contents of their ores the mining companies receive in most cases nothing at all; a large part of the

cobalt produced from the Cobalt mines since their opening has not yet gone into consumption in the arts, and there can be no good reason therefore for valuing the output of this metal at a price which it would not bring in the open market were it put on sale. But this is one of the results which follow from the adoption of the "refined value" basis.

As to the other three items, namely, silver, nickel and copper, there is not much increase in the value of the first as compared with Table I. The value in the latter table is the amount received by the mine owners for their product, as it was marketed month by month, which is not necessarily equivalent to the amount calculated at the average price of silver for the year. As for nickel, it leaves Ontario in the form of matte, and much money and labor is expended upon it in the United States or England before it is put in form to be utilized in the arts. The actual prices at which large sales of refined nickel are made are not often reported in the trade journals, and it may be taken for granted that the prices which are quoted in their columns are in no case less than the reality. It is difficult to arrive at the real value of the nickel as it exists in the matte, for the reason that there is no open market for matte, the refiners being the same or largely the same as the producers. On the one hand, it would not be fair to take the value of refined nickel, say in the New York market, deduct the cost of shipping and refining the matte, and call the remainder the value of the nickel in the unrefined matte, for this would not allow any share of the profit to be allocated to the process of refining. Nor, on the other hand, is it fair to take the value of the nickel in the form of ore as this may be shown in isolated sales,—for there is no market for nickel ore in the same sense as for iron ore, since here also the producers are the smelters—and add to it the cost of roasting and smelting, for this would allow nothing for profit in the latter operations. The proper method would appear to be to take the value of the refined article, as shown by the average price received for sales during any given time, say a calendar year, and in order to find the value of the nickel in the matte, deduct the cost of shipping and refining it and a share of the profit proportional to the cost of refining. Similarly, to get the value of the nickel in the ore, the cost of the necessary treatment after it reaches the pit's mouth, roasting, smelting, etc., and a fair proportion of profit based on the cost of these several operations should be deducted from the matte value of the metal. The data for calculations of this kind are in the hands of the producers of nickel, and it is presumed the values returned by them to the Bureau have relation to the facts. At any rate, the figures set opposite the item of nickel in Table I are the aggregate of those received from the mining companies themselves, though, as has already been remarked, the valuation per pound is lower than it was in 1906, notwithstanding that market quotations for the refined metal remained at the same figure. The value of nickel in the matte as given by the producers in Table I is 10.3 cents per pound, compared with 45 cents per pound, assumed in Table II to be the average value of refined nickel in New York for the year.

The foregoing remarks are largely applicable also to copper, since the great bulk of the copper produced in Ontario comes from the nickel-copper mines of the Sudbury district. Owing, however, to the world-wide production and marketing of copper, its actual value in the refined form is much more easily ascertained. It will be noted that the price at which copper, as given in Table I is valued by the producers is 7.15 cents per pound, as against 20 cents per pound assumed in Table II as being the average value of refined copper in New York during the year 1907.

Table IV shows that the total value of Ontario's mineral production in 1907 on the "refined value" basis was $38,682,472, exclusive of steel. The Geological Survey Department estimates the value of the production of the whole of Canada at $86,183,477, so that Ontario's share was about 45 per cent., or adding the refined value of cobalt as given in the foregoing table to the total production as estimated by the Survey (which gives in the case of cobalt the unrefined value only) the proportion of the whole was 43 per cent.

The output of British Columbia for last year is valued at $25,882,560, the metals being computed at their refined value, less 5 per cent. for silver and 10 per cent. for lead. Of this $7,637,713 is for coal and coke, the total metalliferous output being valued at $17,044,847, as against $28,398,568 for Ontario, on the same basis of computation.

It is therefore apparent that Ontario has taken the lead among the Provinces of Canada in the production of minerals, especially those of a metalliferous character.

Gold

Gold mining in Ontario has not yet reached the status of a profitable industry. The yield in 1907 was 3,810 ounces of bullion, worth $66,399, the contributors to the output being the Shakespeare Gold Mining Company, whose mine is situated in the township of that name, the St. Anthony Gold Mining Company, of Sturgeon lake, and the Imperial Gold Mines, Limited, the company which has been operating the Laurentian mine near Gold Rock in the Manitou region. The last-mentioned property had much the largest production, and its reputed richness has stimulated interest in a number of other prospects in the same region.

The placer deposits on the Vermilion river are still being experimented with by Mr. J. B. Miller and others, under the direction of Mr. R. H. Ahn, but as yet the actual recovery of gold has been unimportant.

Larder Lake Region

None of the claims taken up in the Larder Lake district have yet been placed upon a producing basis, but considerable development work has been done upon some of them, and the ore will shortly be put to the test in stamp mills, one or two of which are going in. So far as can be judged from present indications, the Larder Lake ore will not be high grade, but if the bodies prove to be of good size, the gold contents will probably be sufficient to yield a fair margin of profit. Some excitement was caused in the early spring of the present year (1908) by the exhibition of rich samples of ore from the Harris-Maxwell mine, but these came from a small pocket only, and it is not claimed that the run of the mine will exceed $10 per ton.

Prof. R. W. Brock and his assistant, Mr. N. L. Bowen, made an examination of the district in the neighborhood of Larder lake during the summer of 1907, the former's report being published in the Bureau's Sixteenth Annual Volume. Mr. Bowen remained in the field after Prof. Brock took his departure, and the following notes, summarized from his report, give additional particulars.

A revised map of the region showing the geology and also the claims which have been surveyed on the ground, accompanies this Report.

With respect to the rocks in which gold occurs, Mr. Bowen says:—

The best showings have as yet been found on a band of rusty weathering dolomitic rock. It consists in places almost entirely of lime-magnesia-iron carbonate cut by quartz stringers which have altered some of the carbonate to a green mineral, in places serpentine, in others talc. At other places, again, the amount of carbonate does not exceed twenty per cent., the rock between the quartz stringers being a very hard greenish to grayish material, speckled with pyrite and found under the microscope to consist of plagioclase and orthoclase, comparatively fresh and speckled with carbonate, generally in well formed rhombohedra. A little quartz is present but whether it has come from the stringers or not cannot be determined. The band having these typical characteristics is observed on the Harris-Maxwell, Richardson and Thompson claims, at the south end of Bear Lake, on H S 103, and to the east on some of the claims of the Kerr, Reddick and Chesterville groups. The width varies from over two hundred feet to about twelve feet. On H S 109, near Larder city, and to the south of Spoon's bay, are small outcrops which probably represent the same band. On Diamond lake the typical band is again observed. Smaller outlying patches are noted as at Spoon's bay townsite, and on the shores of Fitzpatrick bay.

Lower Huronian

Mr. Bowen notes that the base of the Huronian for a few feet contains numerous angular to sub-angular fragments of the rock immediately beneath it. On mining claim H J B 32, situated on the north shore of the northeast arm of Larder lake, "the bedded Huronian, almost flat-lying, rests on highly tilted Keewatin schists. The line between the two is quite sharp and a hand specimen may be broken off showing the two rocks. No basal conglomerate was noted. A good section of the Huronian is to be obtained on Chanmanis (Sheminis) hill.[1] This hill, which is such a prominent topographic feature, lies in the Province of Quebec, about one-quarter of a mile southeast of the 40th mile post on the interprovincial boundary. It rises to an elevation of 756 feet above Larder lake[2] and the joint planes have developed cliff faces which afford an excellent section. The lowest rock here observable is a well bedded slate, having a thickness of about 300 feet, overlain by about 150 feet of quartzite, which becomes coarser and coarser, acquiring pebbles and passing into conglomerate which caps the hill with a thickness of 100 feet or more."

The Huronian rocks southwest from Fitzpatrick's bay have been much disturbed, tilted and folded. In the vicinity of Larder city the pebbles in the conglomerate have been squeezed into long lenses; the matrix is quite schistose. In McVittie and McGarry townships the Huronian is also much disturbed.

Post=Lower=Huronian

Mr. Bowen finds that in places the diabase differentiates into pyroxenite, gabbro, diorite and syenite. He notes also the presence of a red feldspar sometimes developed in abundance in the diabase. A thin section from a diabase dike on island A. A. under the microscope was found to consist of plagioclase and hornblende (showing "rests" of monoclinic pyroxene). The hornblende is further altered to actinolite and chlorite. Epidote and ilmenite, partly altered to leucoxene, are also present. A small quantity of quartz in micrographic inter-growth with feldspar occurs. Ophitic texture is marked. Another thin section of the diabase to the southwest is similar to this, but the presence of albite, in addition to basic plagioclase, is noted.

Ores of the Keewatin

Mr. Bowen says that showings of quartz are common in all phases of the Keewatin. Though the quartz stringers in the greenstone carry sulphides, gold does not occur. The quartz stringers in the gold-bearing rock—the rusty dolomitic (?) band—are generally only a few inches wide. A vein two feet wide on the Chesterville group, however, carries fine samples of free gold. It has been traced two hundred feet. Location H S 103 and the original To-ne-ne showing at the south end of Bear lake have characteristic quartz stringers cutting the rusty band and carrying some values.

On the Harris-Maxwell claim the "small branching dike of black trap-like material" mentioned by Prof. Brock is shown by Mr. Bowen to be a tourmaline vein.

South of Larder lake, near the landing on Sharp's creek, the quartz stringers in the Keewatin green schist are much darker in color, and have the appearance of a fine grained marble. Free gold was not found by Mr. Bowen. Sixteen hundred pounds of ore, from a claim in this area (The Combined Goldfields Limited) were sent to the Kingston School of Mining. A mill test returned $8.14 in gold per ton. The ore was the product of the last shot put in. The hole was twenty feet deep.

The "Searchlight Larder Lake Mines," two miles to the southeast of the last named claim is geologically similar to the "Combined Goldfields."

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[1] Bur. Min. Rep. Vol. XI., p. 218.

[2] W. A. Parks in Summary Rep. Geo. Sur. Can. 1904.

Company Holdings

A list of surveyed mining claims held by mining companies operating in this Division has been compiled in the recorder's office from surveyors' lists, as follows:—

Blanche River Mining Co	H. S 1, H S. 51.
Blue Bell Co. (transfers not yet recorded)	S.V. 501 3, 507-13, 516-20, 522-5, and others the survey numbers of which are not known.
Big Pete Canadian Mines	H. F. 31, 34, 36 and others.
Buffalo Larder Gold Mines, Limited	H. S. 158-9, 160 (patented).
Dardanelles Mining Co	H. S. 147, 149, 161, 162, 163, 190.
Cobalt and Larder Lake Gold Mining Co	H. S. 107 to H. S. 111.
Great Northern Larder Lake Mining Co., Limited	H. S. 221 to 234 inclusive.
Harris-Maxwell L. L Gold Mining Co	H. S. 114, 115.
Highland Mary Gold Mines, Limited	H. S. 510 to 539 inclusive.
Imperial Larder Lake Amalgamated Mines, Limited	L. M. 56 to 59; 87 to 97 (not transferred to this Company in Recorder's books).
International Mines	T. C. 1 to 12, R.S.C. 1 to 20, 26 to 32 (not transferred to Co.)
Kerr	H. S. 164, 165, 166.
Le Roi Mining Co., Limited	H. S 79, 80, 86, 235 to 252 inclusive.
Larder Lake Proprietary, Limited	H. F. 37, 38, 39, L. M. 45 to 55 inclusive; L. M 79 to 86 inclusive; H S. 123, 124; H. S. 126, 191; H. F. 35; (L.M. 52, 55 not yet transferred).
Larder Lake Commercial Travellers' Syndicate	H. F. 142 to 151 (not transferred on books).
Larder Central Gold Fields, Limited	H. F. 52 to H. F. 63 (not transferred to Co.)
Little Larder Lake Gold Min. Co., Limited	J. S. 129 to J. S. 140.
Lucky Boys' Gold Mines, Limited	H. S. 128 to 131, 139 to 141, 169, 170, 172, 173, 174, 177, 184, 185, 186, 187, 188, 189, 176, 179 (176 not transferred).
Lincoln-Nipissing Development Co, Limited	C. E. 3, 4, 5, 6; L. M. 8 to 26 inclusive.
Murphy Mines, Limited	H. S. 74 to 78, 81 to 85, 87 to 93.
Martin Larder Gold Mines, Limited	C. E. 120 to 131.
Manhattan Cobalt Mining Co	J. S. 125 to 128, L. M. 60 to 73, H. S. 150, 151, 153, 154, 155, 156, 157.
Northern Larder Lake Mining Co., Limited	H. S. 91, H. S. 200 to 218 (not transferred on books).
North Canadian Gold Mines, Limited	B. G. 204 to 235.
New Liskeard and Northern Ontario Development Co., Limited	J. B 17, 18, 19, 20, 22, 25 and others.
Queen City Mining and Development Co., Limited	L. M. 3, 4, 5.
Reddick Mines	H. J. B. 28 to 33, H. F. 33.
Silver Five Mining Co	H. F. 78 to 85, 86, 87, 90, 91, 92 (not all transferred).
Richardson, W. M	L. M. 30, 31, 32.

The following table shows the course of gold mining in this Province during the last five years:

Table V.—Gold Mining, 1903 to 1907

Schedule.		1903	1904	1905	1906	1907
Mines worked	Number	19	12	13	14	6
Ore treated	tons	32,317	....	17,510	11,791	12,989
Gold product	ounces	10,383	2,285	5,541	3,926	3,810
Gold value	$	188,036	40,000	99,885	66,193	66,399
Men above ground	Number	243	100	175	147	96
Men below ground	Number	250	130	134	97	64
Wages paid	$	245,490	133,000	175,818	152,011	125,537

Silver

As Part II of the Sixteenth Report of the Bureau of Mines contains a revision by Prof. W. G. Miller, Provincial Geologist, of his report on the Cobalt camp, and is being published concurrently with the present volume, it is unnecessary here to deal at any length with the silver production of the Province, which comes almost wholly from the Cobalt mines. Ontario now occupies an important position in the silver-producing communities of the world. Only three states of the Union, viz., Montana, Colorado and Utah, surpassed the output of Ontario in 1907, and the Ontario product is now more than three times that of British Columbia, the only other Province of the Dominion in which silver is obtained in any quantity. The combined yield of Ontario and British Columbia, which for 1907 was about thirteen million ounces, would place Canada ahead of any one of the United States. The world's production of silver is now about 160 millions of ounces annually.[3] Mexico is the largest producer, her

[3] The estimate varies. The Engineering and Mining Journal, New York, January 4, 1908 p. 5, gives the world's production, 1907, as 185,035,436 ounces.

mines yielding last year not far from 58 million ounces, the United States coming next with an output of 56,925,911 ounces in 1907. Australia is third, the famous Broken Hill mine in New South Wales alone producing 5 or 6 million ounces yearly, and Canada, mainly by virtue of the Cobalt mines, takes fourth place.

It is somewhat remarkable that the continent of North America should now be providing more than two-thirds of the world's supply of silver. Europe yields comparatively little, Germany and Spain furnishing yearly somewhat less than Canada. In Asia, Japanese mines yield about $2,500,000 worth per annum; Africa supplies practically nothing; while in South America the famous mines of Bolivia and Peru, which poured out their riches in such profusion during the early days of the Spanish conquest, in 1907 yielded only about $8,000,000 altogether, or very little more than the united production of Ontario and British Columbia.

Markets for Silver

But if the countries of the East produce little silver, they purchase large quantities, being indeed the dominating factor in the market. The course of silver prices was for some three or four years previous to the later months of 1907—or practically ever since the beginning of the Cobalt production—almost constantly upward, reaching nearly 70⅛ cents per ounce early in the year, then receding a little, but rising again to over 68 cents in August. The autumn months saw a rapid decline, and the year closed with an average price for December of 54.565 cents. The maintenance of the higher level during the earlier part of the year was doubtless due in large measure to the steady demand prevailing for some time from India, both for coinage and trade purposes, but, early in October, the partial failure of the rains in that country made it apparent that only a moderately good crop could be hoped for. The Indian bazaars then instead of buying, began to sell silver, and as the London market was heavily stocked and other demands were light, the pressure to realize brought about a fall in price. The downward tendency was accentuated by the high rates of interest current during the closing portion of the year, the Bank of England rate being 7 per cent. from early in November until 31st December, a point that had not been touched since 1870.

The important influence of India on the silver market may be realized when it is stated that the imports into that country in 1906 amounted to $73,898,225 worth, and in 1907 to 85,878,884 ounces, worth about $50,000,000. A large part of the silver bought by India is hoarded by the people of that country, when prosperity prevails, chiefly in the form of ornaments and objects of native manufacture. In times of scarcity or famine, some of this silver is thrown upon the market, though the hoarding process which has been going on for centuries, never wholly ceases. Thus the hunger of the ryots of Bengal may close a silver mine, or many silver mines, in America. China, too, is a great user of silver, largely as currency, both in the form of sycee, or native bullion, (about 98 per cent. fine), and Mexican dollars, which are current all over the empire, and also in Malaysia. A considerable part of India's requirements in 1907 was supplied by China, much of the silver poured into Manchuria during the Russo-Japanese war finding its way to treaty ports for export.

The prosperity of the Cobalt mining camp, however, much less its existence, does not depend upon a high price for silver. The ores of Cobalt are so much richer than the average that many of the mines could continue to produce silver even in the face of a still further lowering of its value. Yet it goes without saying that a restoration of better prices for silver would be welcome in Cobalt, where the ores are valuable almost wholly for their silver contents, in this respect differing from many other sources of supply, in which silver is a by-product of lead, copper or gold. Taking the world as a whole, doubtless most of the silver is obtained from mines which are operated in the first instance for other metals. An increase in the price of lead or copper stimulating the production of these metals, leads to a larger yield of silver, with the consequent possibility of lower prices for the latter.

The Mines of Cobalt

The output of silver in Ontario last year was 10,028,259 ounces, having a value according to returns received from the mining companies of $6,157,871. Compared with 1906, when the production was 5,433,984 ounces, worth $3,689,286, the gain in quantity was 85 per cent., but owing to the fall in price, there was an increase in value of only 68 per cent. The shipments of ore amounted to 14,809 tons, so that on the average the ore shipped out contained 677 ounces of silver per ton, and had a value of $416. The average value of the ore taken out in 1907 was considerably less than in 1906; indeed, in this particular, as was to be expected, there has been a progressive decline since the opening of the mines. The following figures giving the average contents of the ore shipped each year show this to be the case:

	Ounces.
1904	1,309
1905	1,143
1906	1,013
1907	677

It does not, however, follow that the ores are becoming poorer. In the early days of the camp only the rich ore containing native silver in nuggets and plates was sent out, but in 1906 and to a still greater extent last year, ore containing as low as 150 ounces per ton or less was freely marketed. Probably as much high grade ore was shipped in 1907 as in any previous year, but there was also sold a greater quantity of screenings and other material having a much less average value. A considerable tonnage of this low grade product was shipped to the American Smelting and Refining Company's works at Denver, Colorado, where it has been found suitable for mixing with certain of the ores of the Western States.

The producing mines of the Cobalt camp in 1907 were 28 in number, and are here given in the order of the value of their production: Nipissing, O'Brien, Coniagas, La Rose (including Lawson), Kerr Lake, McKinley-Darragh-Savage, Buffalo, Trethewey, Temiscamingue, Temiscaming and Hudson Bay, Drummond, Right-of-Way, Foster, Cobalt Silver Queen, Nova Scotia, Green-Meehan, City of Cobalt, King Edward, Cobalt Townsite, Silver Leaf, University, Standard Cobalt (Cobalt Central), Colonial, Nancy Helen, Temiscaming Cobalt, Red Rock, Imperial Cobalt. The shipping mines in 1904 were four in number; in 1905 sixteen; in 1906 seventeen, and in 1907 twenty-eight. Since the beginning of 1908 several others have been added to the list, among them the Crown Reserve, Casey Cobalt and Provincial mine. In point of tonnage, there has been a rapid increase year by year, as is shown by the following table, which also summarizes other features of interest. The figures are for the Cobalt camp only, and do not include small quantities of silver produced by the mines of the Lake Superior region, or obtained from the Sudbury nickel-copper mattes:

Table VI.—Silver Production Cobalt Mines 1904 to 1907

Year.	Producing mines.	Ore shipped.	Silver contents.	Value silver.	Average silver contents per ton.	Average silver value per ton.
	No.	Tons.	Ounces.	$	Ounces.	$
1904	4	158	206,875	111,887	1,309	708.14
1905	16	2,144	2,451,356	1,360,503	1,143	634.56
1906	17	5,335	5,401,766	3,667,551	1,013	687.07
1907	28	14,788	10,023,311	6,155,391	677	416.24
Total		22,425	18,083,308	11,295,332	806	503.69

The Labor Question at Cobalt

The production of the Cobalt mines in 1907 was probably less than it would have been but for the labor troubles which broke out in July. The demands of the men for higher wages not having been granted by the mining companies, a strike was

declared by the miner's union, a branch of the Western Federation of Miners. Feeling ran high for some time, but there was little in the way of violence, this freedom from crime being no doubt in part due to that provision of the mining law enacted in 1900, which provided that no new licenses for the sale of intoxicating liquor should be issued within six miles of a producing mine. As the discoveries at Cobalt had not then been made and there was no settlement there in 1900, the camp has developed to its present stage with an entire absence of the legalized sale of liquor, and up to the present time Cobalt, though with a full share of the adventurous and boisterous spirits which a "booming" camp invariably attracts, has had a record for the observance of law and order surpassed by scarcely any rural part of Ontario. There have been no murders, and few assaults, and even amid the stress and strain of a bitter strike, practically no violence was done on either side. The agitation in favor of higher wages was not successful, for though a few mines granted the union scale of pay and hours, the majority continued at work on the old terms.

Table I shows that 2,038 men were employed in the Cobalt mines in 1907. An organization, known as the Mines Free Employment Bureau, acts as middleman in supplying labor to the mines. Men out of employment register at the Bureau's office, stating the kind of work they want, their qualifications, experience, etc. Mine managers desiring hands apply to the Bureau for machine men, muckers, mechanics, etc., and are furnished with the help required, taking the men in the order of their registration. The system has been found to answer well, and to be a great convenience both to managers and to men. Mr. W. R. Mackan, manager of the Bureau, in response to an enquiry furnished under date of 16th February, 1908, a statement showing the number of men employed in the mines of Cobalt, and the capacity in which they were severally employed. The list is here given, as showing the labor requirements of the camp and also the high stage of development already reached in the subdivision of labor in the mines: Surface foremen 23; mine captains 29; shift bosses 51; head carpenters 15; carpenters 76; carpenters' helpers 18; master mechanics 17; mechanics 20; pipe-fitters 24; pipe-fitters' helpers 13; blacksmiths 57; blacksmiths' helpers 52; engineers 60; firemen 49; head ore sorters 18; ore sorters 107; hammermen 36; teamsters 57; hoistmen 58; bucket tenders 67; timbermen 35; timbermen's helpers 10; machine men 203; machine men's helpers 165; muckers 149; trackmen 11; surface laborers 114; other employees 189; total 1,714. Mr. Mackan adds that some of the smaller mines were closed down at the time of writing, and that in his opinion it would be fair to add about 300 men to this number, which would take in men engaged in prospecting at that date, and also those who were temporarily out of work.

The growth of the Cobalt camp as a field for the employment of labor is shown by the following figures:

Year.	Number of men employed.		Wages paid.
	Above ground.	Under ground.	
			$
1904...........	29	28	12,300
1905...........	289	186	191,582
1906...........	471	586	581,253
1907..........	1,201	826	1,525,019

In his interesting report to the Temiskaming and Northern Ontario Railway Commission for the year 1907, Mr. Arthur A. Cole, the Commission's mining engineer, gives the following particulars regarding the power requirement and equipment of the Cobalt mines:

Horse power boiler capacity of the Cobalt camp at end of

Year	H. P.
1904	Zero
1905	150
1906	3,406
1907	7,918

The mines of the district now have 74 steam plants and two gas producer plants, and in connection with these are 51 compressor plants, as compared with 20 at the end of 1906. A favorable result of the installation of this machinery is that more development than formerly is being done per ton of ore shipped and there is to-day more ore blocked out than there was a year ago.

A somewhat unexpected feature in the operations of the mines is the fact that in this camp, situated in a dense forest, the prevailing fuel for boiler consumption is coal. The use of wood has been practically abandoned. The reasons for this are the absence of hard wood,—the only available timber for fuel purposes being the smaller conifers such as tamarack, balsam and jack pine, which when dry give a hot fire but do not last long in the furnace;—the high cost of cutting and hauling wood; and the superior convenience of coal, which is brought in in carlots, and in a number of mines, switched direct to the power house or fuel bins.

Concentrating Low-grade Ores

The utilization of the low grade ores of the Cobalt silver mines is now assuming much importance. Many of the mines have accumulated dumps of considerable magnitude, the silver contents of which are far from negligible. To meet the situation thus arising, four of the mining companies have installed concentration plants, all of which were either in operation or on the point of completion at the end of the year. Following are the companies which have installed milling plants: The Buffalo Mines Company, Limited; Standard Cobalt Mines, Limited, at the Cobalt Central mine; Coniagas Mines, Limited; and McKinley-Darragh-Savage Mines of Cobalt, Limited.

Two custom concentrating plants are also in course of construction, belonging respectively to Muggley Concentrators, Limited, and Cobalt Concentrators, Limited.

The concentration in all cases is by water, except in that of the Cobalt Concentrators, where a pneumatic process is employed.

In addition to the foregoing local plants, several reduction works for the further treatment of the Cobalt ores are under way in various parts of the Province. The Orford Copper Company's plant at Copper Cliff has been in operation since 1906. It treated 2,266 tons of ore last year, most of which was high grade material. The Deloro Smelting and Reduction Company which purchased the gold-arsenic reduction works at Deloro, Hastings county, and equipped them for treating the ores of Cobalt, were in the market for ore about the end of the year, and have been operating since early in 1908, principally on ore from the O'Brien mine, the owners of which are also interested in the reduction plant. This company has been successful in producing bar silver up to .998 fineness which it markets in London, England, but so far has not made any attempt to separate the cobalt and nickel, which are retained in the residues. At Thorold the Coniagas Reduction Company expect to have their plant in operation early in the summer of 1908. Their purpose is not only to recover the silver, but also to manufacture cobalt and nickel oxides, and white arsenic. Large holders of shares in Coniagas Mines, Limited, are connected with this company. The smelters at Trout Lake and Sturgeon Falls have not yet begun to treat ore.

Ore Purchasing Concerns

The principal purchasers of ore in 1907 were the American Smelting and Refining Company, and the Orford Copper Company. All of the ore bought by the latter was sent to Copper Cliff, Ont., for treatment, while the former shipped most of its tonnage to its works at Perth Amboy, New Jersey, but a proportion also of low grade ore to its plant at Denver, Colorado. The purchasing tariffs of the several buying companies may be summarized as follows:

American Smelting and Refining Company: For ores under 1,500 ounces silver per ton, pay for 93 per cent silver contents at New York price 30 days after agreement of assays, less working charge of $9 per ton plus one-half cent per ton for each ounce of

silver contained. If arsenic in excess of 5 per cent., working charge increased 25 cents per ton for each per cent. of arsenic so in excess. Seven cents per ton added to working charge for each per cent. of insoluble matter contained in excess of iron.

For ores 1,500 ounces silver per ton and over: Pay for all silver recovered at New York quotations on date of production of bars, and for 98 per cent. of silver in all by-products such as slags, test bottoms, etc., 30 days after agreement of assays less a working charge of $125 per ton plus one cent per ounce of silver paid for.

The freight on ore from Cobalt to Perth Amboy is $10.20 per ton, and on shipments to Denver a reduction in working charge is made to equalize freight.

Orford Copper Company: Pay for 94 per cent. of silver per ton of ore containing 4,000 ounces and over, 93 per cent. for ore containing 1,200 ounces and over, 92 per cent. 800 ounces and over, 90 per cent. 500 ounces and over, 85 per cent. 300 ounces and over, 80 per cent. 150 ounces and over; also for cobalt $30 per ton of ore containing 12 per cent. cobalt or over, $20 per ton containing 8 per cent. or over, $10 per ton containing 6 per cent. or over. Payment made of 50 per cent. value silver and cobalt at New York price 45 days after sampling completed, remaining 50 per cent. 45 days later.

Freight on ore from Cobalt to Copper Cliff is $5.20 per ton.

Deloro Smelting and Reduction Company: Pay for 95 per cent. of silver per ton assaying 2,000 ounces and over, 94 per cent. 1,000 to 2,000 ounces, 93 per cent. 800 to 1,000 ounces, 91 per cent. 500 to 800 ounces, 90 per cent. 200 to 500 ounces, 85 per cent. 100 to 200 ounces, at New York quotations 30 days after agreement of assays; 1 cent per pound for arsenic in ore containing 10 to 30 per cent., 1½ cents per pound in ore containing 30 per cent. arsenic and over; also $10 per ton of ore containing 6 to 10 per cent. cobalt, and $20 per ton containing 10 per cent. or over.

Freight from Cobalt to Marmora (station for Deloro), $7 per ton.

The Balbach Smelting and Refining Company of Newark, New Jersey, United States Smelting, Refining and Mining Company of Chrome, New Jersey, and Pennsylvania Smelting Company of Carnegie, Pennsylvania, also bought consignments of ore during the year.

Of the ore shipments from the camp in 1907, 81.47 per cent. went to the United States, and 17.40 to Canadian reduction plants (practically all to Copper Cliff). The remainder, 1.13 per cent., was silver-free cobalt ore which was shipped to England.

Shareholders in Cobalt mining companies have up to 31st December, 1907, realized $3,847,344.19 in dividends and bonuses. Of this $1,954,450 was paid in 1906 and $1,892,894.19 in 1907. Details of payments in 1906 were given in the Sixteenth Report of the Bureau of Mines, Part I, page 13, and similar particulars regarding the dividends of 1907 will be found in Part II of the same Report, so that it is unnecessary to repeat them here. These sums do not include the returns made to the owners of La Rose and Drummond mines, which are close corporations, or the profits realized by the owners of the O'Brien mine, which would bring the whole amount up to about five millions of dollars.

Cobalt: Nickel: Arsenic

The constituents of the Cobalt ores other than silver do not bulk largely in the figures of value. Nothing is realized by mine owners on the nickel contents, very little for the arsenic, and not much for the cobalt. When the last-named element comprises less than 6 per cent. by weight of the ore shipments, it is disregarded in the smelter returns, if in excess it is paid for at the rate of $10 to $30 per ton of ore, according to the proportion of cobalt. Only one company purchasing Cobalt ores, the Deloro Mining and Reduction Company, pays anything for arsenic. If over 10 per cent. and under 30 per cent. by weight, this company allows one cent per pound for the arsenic contents; if over 30 per cent., one and a half cents per pound.

The mining companies, receiving so little for these ingredients, are at no pains to ascertain how much their shipments contain, and as in many cases no assay is made or reported for nickel, cobalt or arsenic, there is no means of ascertaining exactly what quantities of these substances are shipped out of the Cobalt district. In the last Report of the Bureau the percentages adopted for tabulation purposes were 6 per cent. for cobalt, 3 per cent. for nickel, and 27 per cent. for arsenic. The low grade ores, such as comprised a considerable proportion of the shipments of 1907, contain not only less silver, but less cobalt, nickel and arsenic than the ores of higher grade, hence the lowering of the average silver contents implies also a lowering of the other mineral constituents. It is not possible to estimate precisely the extent to which these substances have fallen, but it is probable the level for 1907 would be found at not far from 5 per cent. for cobalt, 2½ per cent. for nickel, and 20 per cent for arsenic, and these proportions have been assumed in compiling the statistics of last year.

The production of the Cobalt mines, including all the constituents of value, since they were opened, is shown in the following table:

Table VII.—Total Production Cobalt Mines 1904 to 1907

Year.	Ore shipped.	Nickel.		Cobalt.		Arsenic.		Silver.		Total Value.
	Tons.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Ounces.	Value.	
			$		$		$		$	$
1904	158	14	3,467	16	19,960	72	903	206,875	111,887	136,217
1905	2,144	75	10,000	118	100,000	549	2,693	2,451,356	1,360 503	1,473,196
1906	5,335	160	....	321	80,704	1,440	15,858	5,401,766	3,667,551	3,764,113
1907	14,788	370	1,174	739	104,426	2,958	40,104	10,023,311	6,155,391	6,301,095
Total	22,425	619	14,641	1,194	305,090	5,019	59,558	18,083,308	11,295,332	11,674,621

The overwhelming proportion of silver as compared with the other constituents of the Cobalt ores is well shown by the above table. The returns from silver were 97 per cent. of the whole.

The total output of silver in 1907 was 10,028,259 ounces, a small production being reported from one of the mines in the Port Arthur region. The rise and progress of the Cobalt camp has revived a certain interest in the latter area, once the scene of much activity, but as yet there has been no resumption of production on any considerable scale.

Montreal River Silver Field

The discovery of silver-cobalt-nickel ores on the Montreal river in and near the township of James drew a large number of prospectors to that region last year. A considerable number of such finds were made, and there seems good reason to believe that the ore exists in quantity and quality sufficient to pay for working. Access to the district is not difficult, the route by canoe up the Montreal river from Latchford station on the Temiskaming and Northern Ontario railway being a good one with few portages. There is also an overland route from Charlton, the terminus of a spur of the same railway, and should the promise of richness which the district now holds out be realized, an extension of this spur to the Montreal river would afford the necessary rail connection. At present machinery and supplies are somewhat expensive to transport, especially as compared with the early days of Cobalt, through which camp the railway ran from the start, and to some extent this is retarding the progress of the field. Near Anvil lake, south of James township, the White brothers discovered rich ore in 1906, and it is understood their claims have been sold for a good figure this spring (1908). Round Silver and Hubert lakes a number of promising claims have been staked out showing native silver and cobalt. Further west on the east branch

of the Montreal river, prospectors last year found good ore of similar character on and in the neighborhood of Bloom lake, and this region is likely to attract considerable attention during the coming season. With commendable enterprise the pioneer prospectors of Bloom lake have built by their own labor a road about 15 miles long leading from Elk lake on the Montreal river to Bloom lake. A large part of this whole region is in the Temagami Forest Reserve, prospecting and mining in which are regulated by the Government with the view of protecting and preserving the timber. Searching for minerals can only be carried on by authority of a permit issued by the Department of Lands, Forests and Mines, and the Mining Act forbids the sale of lands within the Reserve. A lease, however, of a mining claim can be granted renewable for ten-year periods, which enables the minerals to be worked.

The results of a geological exploration carried on last year, in the Temagami Reserve and Montreal River district, under the direction of the Provincial Geologist, are presented in the Sixteenth Report, Part II, where fuller details are given. The colored map accompanying that Report has already been published, so that prospectors going into the district may take it into the field with them next spring. A black and white map of the Bloom lake region has also been issued, showing the route into the region, the claims which have been surveyed, etc. This also, it is hoped, will be of service to prospectors.

Silver Finds South of Lorrain

The newest silver camp in the Province lies south of the township of Lorrain, which occupies a considerable portion of the west shore of lake Temiskaming. In the summer of 1907 a good vein of cobalt ore unaccompanied by silver was found on a claim about three miles west of the lake, since surveyed as H R 16, owned by the Haileybury Silver Mining Company, while on H R 19 (Keeley or Jowsey claim) near by, a considerable quantity of wire silver was struck along with cobalt bloom. Some 10 or 11 tons of this wire silver ore was bagged early in 1908. Owing to the thick covering of snow which effectually obscures the surface of most of northern Ontario in the winter time, it has hitherto been impracticable to satisfactorily determine the geology of this region, but in March of the present year, while the snow was still on the ground, Mr. C. W. Knight, Assistant Provincial Geologist, made a brief examination of the productive area, which seemed to show that it was in proximity to a diabase contact with prevailing country rock of Keewatin age. One or two claims nearer lake Temiskaming have been reported as showing native silver in small quantity. It is proposed to study the district in greater detail during the approaching season, and to issue a geological map and report as soon as possible. Winter prospecting, or at any rate winter staking, has been active in this region as a result of the discoveries and already stakes have been planted covering the territory as far south as the mouth of the Montreal and Metabitchewan rivers.

Provincial Mine

A memorandum showing the progress of work at the Government Provincial mine on the Gillies limit up to the end of 1907 is furnished by Mr. E. T. Corkill, who has been associated with Prof. Miller in the management of the mine:

When work was commenced by the Bureau of Mines on the Gillies limit in 1906, there were rumors of very rich silver finds having been made during the previous year by prospectors, who had gone on the limit without permit. All such reported finds where any work has been done were examined by trenching, etc., but no veins of value were uncovered. In some cases prospectors who claimed to know of solid veins of silver on the limit showed their finds to us on the understanding that they would receive $150 an inch in width for veins running over 500 ounces in silver. All these parties were unable to show us veins of any value, in fact anything that was shown us were mere cracks in the rock. Several veins were found by us in trenching, but the most promising was discovered near the northwesterly boundary under 4 or 5 feet of earth on July 19th, 1906.

During the year 1906 very little actual mining work was done. During the months of July to October, 1906, about twenty men were employed continuously, trenching about 18,000 feet. Several test pits were put down and three small shafts were sunk 10, 30, and 55 feet respectively. In the 55-foot shaft to the west of the railway 45 feet of drifting and cross-cutting was done on the 55-foot level.

In addition to actual prospecting the northern portion of the limit was surveyed and mapped in 1906, and the main shaft on the vein found adjoining the Nipissing property was begun.

Owing to the failure of the machinery companies to deliver the machinery according to contract, and the labor difficulties in the Cobalt camp in 1907, very little work was done at the mine between April and September of that year.

Owing, too, to construction work on the Kerr Lake branch of the T. & N. O. railway, which passed within 200 feet of our mine buildings, the danger from blasts on the railway retarded operations at the mine greatly, as these could only be carried on with jeopardy to the lives of the workmen. The work at the mine up to the end of 1907 shows the following:

The shaft has been sunk 140 feet with levels at 65 and 125 feet respectively. The shaft is timbered for its entire depth with square sets and the hoist way provided with guides for cage.

On the first level 450 feet of drifting has been done and 70 feet of cross-cutting. A raise has also been put through to the surface 50 feet east of the shaft on the vein, and timbers put in and stoping begun for 90 feet along the vein.

On the second level at 125 feet in depth 25 feet of drifting and cross-cutting has been done.

At the mine, buildings have been erected consisting of boiler house 32 × 50 feet, bunk house, two stories, 20 × 50 feet, dining room, office, ore house, blacksmith shop and shaft house.

The machinery installed consists of a 100-h.p. return tubular Jenckes boiler, the high pressure half of a Rand air compressor developing 500 cubic feet of free air per minute. The concrete foundation for the complete compressor has been put in, and also a 7 × 10-inch Jenckes hoist. In the mine a Worthington pump has been placed on the first level, and a Cameron sinking pump on the second. Five air drills have been purchased and three are kept continuously in operation. In addition to these the mine is thoroughly equipped with piping, tracks, steel for drills, air hose, etc.

At the present time the ore is being broken down in the stope on the first level, but very little can be taken out until the stope has been carried through to the surface when the rock and ore will be drawn from the stope and ore picked out and sacked. About 60 feet more drifting will be necessary on the second level before the vein is cut.

About 25 men are at present employed.

Nickel

There were 10,972 tons of nickel produced in Ontario in 1907, practically the same quantity as in 1906. By far the greater portion of the output was from the nickel-copper mines of the Sudbury district, the only other source of the metal being the mines of Cobalt, from which the production is estimated at 370 tons.

The Canadian Copper Company remains the largest operator in the nickel field. With large deposits of high-grade ore, an extensive and well equipped plant both for mining and smelting, and ample means at its command, this company occupies a very strong position as a producer of nickel. The quantity of ore raised by the Canadian Copper Company was 303,256 tons, of which 238,948 tons were from the Creighton mine, and 61,081 tons from the Crean Hill mine, which began production last year. The remainder came from the old No. 2 mine at Copper Cliff. The Mond Nickel Company mined 48,660 tons of ore wholly from Victoria mine No. 1. The quantity of Bessemer matte produced by these companies was 22,041 tons, the average contents of which were 48 per cent. nickel and 32 per cent. copper. Both plants were in operation during the whole of the year, the number of employees being 1,660, and the wages paid out $1,278,694. The Mond Company is developing a water power for operating its mine and works at Wabageshik falls on the Vermilion river in the township of Lorne. The nickel-copper mines of Sudbury have given Ontario first place among the nickel producing countries of the world, far surpassing the only other source of supply, the island of New Caledonia. The garnierite or nickel silicate of New Caledonia is a very different mineral from the pyrrhotite of Sudbury, in which the

nickel occurs as a sulphide, principally pentlandite, and the treatment of the two classes of ore is very unlike. The roast yards at Copper Cliff or Victoria Mines show huge heaps of burning ore slowly exhaling tons of sulphur in the most acrid of fumes, withering every green blade within their influence. In smelting the New Caledonia ore, on the other hand, it is necessary to add sulphur. Along with the nickel in the Sudbury ores is found a nearly equivalent proportion of copper, while in the New Caledonia mineral nickel is the sole element of value. The ore is exported as such from New Caledonia, but although the Canadian ore is smelted to a Bessemer matte at the mines, the final processes of refining and separation take place abroad, the Canadian Copper Company's refinery being in New Jersey, and the Mond Nickel Company's in Wales.

Table VIII summarizes the progress of nickel-copper mining in Ontario for the last five years:

Table VIII.—Nickel-Copper Mining 1903 to 1907

Schedule.		1903	1904	1905	1906	1907
Ore raised	tons	152,940	203,388	284,090	343,811	351,916
Ore smelted	"	220,937	102,844	257,745	340,059	359,076
Ordinary matte produced	"	30,416	19,123	....	....	....
High grade matte produced	"	14 419	6,926	(a) 17,388	(a) 20,364	(a) 22,041
Nickel contents	"	6,998	4,743	9,503	10,776	10,602
Copper contents	"	4,005	2,163	4,525	5,260	7,003
Value of Nickel	$	2,499,068	1,516,747	3,354,934	3,839,419	2,270,442
Value of Copper	"	583,646	297,126	688,993	806,113	1,020,913
Wages paid	"	746,147	570,901	833,822	1,117,420	1,278,694
Men employed	No.	1,277	1,063	1,176	1 117	1,660

(a) Bessemer matte.

The reduced valuation placed on the nickel contents of the matte by the mining companies as compared with 1906, already spoken of, is very noticeable in the above figures. Nickel in the matte a year ago was worth according to these returns 17.8 cents per pound, whie in 1907 it was worth only 10.7 cents per pound, notwithstanding that the price of the refined metal, according to published quotations was quite as high in 1907 as in 1906.

In roasting the ore and as fuel for other purposes 28,435 cords of wood valued at $77,366, or $2.72 per cord, were consumed last year, also 63,899 tons of coke worth $462,204 in smelting the ore into matte. Without allowing for the loss of metallic contents in roasting and smelting, the ores converted into Bessemer matte contained an average of 2.95 per cent. of nickel and 1.95 per cent. of copper, as compared with 3.16 per cent. of nickel and 1.54 per cent. of copper in 1906. This shows a reduction of .21 per cent. of the former, but an increase of .41 per cent. of the latter metal.

Copper

Most of the copper produced in this Province comes from the nickel-copper mines of Sudbury, but a varying quantity is obtained year by year from the non-nickeliferous copper deposits in other districts, principally on the north shore of lake Huron. The heavy fall in the price of copper which ruled for electrolytic 25.070 cents per pound in the New York market in March, but which dropped to 13.277 cents per pound in December—a decline of 47 per cent.—had a tendency to discourage the production of the metal. The quantity of ore raised by four copper sulphide mines in 1907 was 9,575 tons, containing about 300 tons of copper, or an average of a little over 3 per cent. These mines were the Bruce mines, owned by the Copper Mining and Smelting Company of Ontario, the Hermina, the Tip-top, and the Cobden Copper Mining Company's mine in the township of that name. The Superior and Bruce mines together produced 370 tons of concentrates containing about 72 tons of copper, and valued at $24,598.

Following are the figures of production from the copper sulphide mines:

Ore raised	tons	9,575
Estimated copper in do	"	300
Concentrates produced	"	370
Estimated copper in do	"	72
Value of do	$	24,598
Workmen employed	No.	164
Wages paid	$	105,333

Iron Ore

The quantity of ore raised and shipped from the iron mines of the Province during the year 1907 was 205,295 tons, valued at $482,532, as against 128,049 tons worth $301,032 in 1906. The output was composed of 157,715 tons of hematite and 47,580 tons of magnetite. The hematite was the product entirely of the Helen mine at Michipicoten, while the magnetite came from the mines of the Mineral Range Iron Mining Company at Bessemer, Hastings county, the Atikokan Iron Company at Atikokan, the Wilbur Iron Ore Company at Wilbur, Lanark county, and the Canada Iron Furnace Company at Radnor, Renfrew county. All of these mines, except the Wilbur, are operated by or in connection with companies producing pig iron. The Helen ore is exported mainly to the United States, where in effect it is exchanged for ore suitable for the manufacture of steel rails by the Algoma Steel Company at Sault Ste. Marie; the produce of the Bessemer mines, now being operated by the Canada Iron Furnace Company, is smelted in the company's blast furnace at Midland, while the ore from the Radnor mine goes to the same company's furnace in Quebec; the Atikokan magnetite after roasting is smelted by the Atikokan Iron Company at Port Arthur; and the product of the Wilbur mine, which is of Bessemer quality, is shipped to Sault Ste. Marie for use in making pig iron for steel rails.

The Moose mountain deposit of magnetite has as yet made no shipments of ore, but the completion of the branch of the Canadian Northern railway into the mine and of the docks and ore pockets at the Key on French river will allow of the product being placed upon the market. A large bed of bog ore is reported from near Niblock station on the main line of the Canadian Pacific railway west of Port Arthur; good samples of magnetite have been brought out from the neighborhood of Emerald lake in the Temagami Forest Reserve, and a considerable body of ore is said to have been found some distance north of Savant lake about twelve miles from the line of the National Transcontinental railway. None of these deposits however have in any way been proven. On the old Blairton mine property in the township of Belmont, Peterborough county, diamond drilling is said to have disclosed a considerable body of hematite.

Messrs. Coleman and Moore, on behalf of the Bureau of Mines, continued their exploration of the Iron ranges east of lake Nipigon, and in the present report give an account of their work. There are still considerable stretches of Iron formation in that district to be examined, and it is probable these gentlemen will return to the same field during the season of 1908.

For a full account of the iron industry of Ontario, and its productive capacity both in iron ore and pig iron and steel, reference should be had to the article in the present volume on the subject by Mr. George C. Mackenzie, who has had a wide and practical experience in the iron business.

Table IX gives particulars of the production of iron ore for the five years 1903 to 1907 inclusive:

Table IX.—Iron Ore Production 1903 to 1907

Schedule.	1903.	1904.	1905.	1906.	1907.
Ore shipped ... tons	208,154	53.253	211,597	128,049	205,295
Value of ore shipped ... $	450,099	108,068	227,909	301,032	482,532
Men employed ... No.	324	191	278	204	276
Wages paid ... $	166,457	84,673	164,153	125.391	192.063

Pig Iron and Steel

There were seven blast furnaces in operation in 1907, viz., two owned by the Algoma Steel Company at Sault Ste. Marie, two by the Hamilton Steel and Iron Company at Hamilton, and one each by the Canada Iron Furnace Company, the Atikokan Iron Company and the Deseronto Iron Company at Midland, Port Arthur and Deseronto respectively. The last named, however, was in blast for a short period only, while one furnace at Sault Ste. Marie and one at Hamilton were blown in during the year and did not run for the whole twelve months. The output of the furnaces was a total of 286,216 tons of pig iron valued at $4,716,857, as compared with 275,558 tons, worth $4,554,247 in 1906. The production of steel which comprised castings and ingots by the Hamilton Steel and Iron Company, and steel rails by the Algoma Steel Company, amounted to 237,855 tons, valued at $4,168,127.

At Welland the manufacture of steel by the basic open hearth process has been begun by the Ontario Iron and Steel Company. This company will not operate a blast furnace, but will purchase its supplies of pig in the open market.

The Electro-Metals Company has also located works at Welland for the manufacture of ferro compounds, and the production of pig iron by the electric process. The plant went into partial operation in December, 1907, the product being ferro-silicon, quartz for which was brought from the feldspar quarries on the Kingston and Pembroke railway near Verona. It is proposed also to make ferro-chrome and ferro-tungsten.

Particulars of the operation of the blast furnaces and steel works for the year are as follows:

Ontario ore smelted	tons	120,156
Foreign " "	"	388,727
Scale and mill cinder	"	22,806
Limestone for flux	"	171,057
Coke for fuel	"	326,937
Value of do	$	1,748,090
Charcoal for fuel	bush.	1,849
Value of do	$	221
Pig iron product	tons	286,216
Value of do	$	4,716,857
Steel product	tons	237,855
Value of do	$	4,168,127
Workmen employed	No.	1,242
Wages paid	$	808,681

The proportion of Ontario ore used in making pig iron was 23.6 per cent. in 1907, as against 20 per cent. in 1906. With the easy water carriage provided by the great lakes which form the southern boundary of Ontario, it will probably continue to be more advantageous to import iron ore for use at given points on or contiguous to the shores of these lakes, than to bring it by rail for great distances inland, especially ores required for given mixtures or for special grades of pig. For the same reason, it may often be more profitable to export ore to the United States from points not well situated as regards blast furnaces than to pay freight upon it to smelters in Ontario. Thus, it is likely there will always be a movement of ore to and from both sides of the boundary line; nevertheless it is matter for regret that after 12 years' active and constantly growing manufacture of pig iron since the revival of the industry in 1896, less than one-quarter of the ore charged into the furnaces of Ontario is of domestic origin. The scarcity of hematite in that part of the Province south and east of the Georgian bay, in which the majority of the furnaces have hitherto been situated, doubtless accounts for much of the imports from the United States, since furnace men in Ontario have modelled their practice upon methods in use south of the line, where the manufacture of pig iron and steel is based upon the existence of an abundant supply of first rate hematite and has developed accordingly.

The situation, however, shows signs of improvement. The opening up of bodies of good magnetic ore of considerable size, some of it of Bessemer quality, is placing supplies of excellent raw material at the disposal of smelting establishments which should tend to free them from dependence upon foreign sources. The market for manufactures of iron and steel which the settlement of northern Ontario and Northwest Canada will create affords conditions for the building up in Ontario of a great industry

in the production of these staples which could hardly be surpassed, provided the necessary supplies of ore exist here. The known deposits have been materially added to during recent years, and as the exploration of the great stretches of iron-bearing rocks in northern Ontario proceeds, they can scarcely fail to be still further multiplied.

Statistics regarding the manufacture of pig iron and steel during the five years beginning with 1903 are given in the following table:

Table X.—Production Iron and Steel 1903 to 1907

Schedule.		1903.	1904.	1905.	1906.	1907.
Ontario ore smelted	tons	48.092	50,423	61,960	101,569	120,156
Foreign ore smelted	"	103.137	173.182	383.459	396,463	388,727
Limestone for flux	"	49,426	61 566	121.052	153,702	171,037
Coke	"	96,540	135,108	262,415	304,676	326,937
Charcoal	bush	932.630	1,821 270	3,387,869	811,926	1,849
Pig iron	tons	87,004	127,845	256,704	275,558	286,216
Value of pig iron	$	1,491,696	1,811,664	3,909.527	4,554,247	4,716,857
Steel	tons	15,229	51,002	138,387	167,026	237,855
Value of steel	$	304,580	1,188,349	3,321,884	4.202,278	4.168,127

These figures show that the quantity of pig iron made in 1907 was 275 per cent. more than in 1903, and other items of production have increased correspondingly.

Materials of Construction

The chief material used in Ontario for houses and other structures for occupation is brick, clay for the manufacture of which is found widely distributed throughout the Province, especially in the older and less rocky portions. The output of the brick yards last year in common and pressed brick had a value of $2,758,666, as compared with $2,494,795 in 1906. Prices of common brick rose considerably during the year, being on an average $7.70 per thousand as against $7.19 in 1906.

That there has been a steady advance in the prices of brick for a number of years is clearly seen from the following figures, showing the average price of common bricks per thousand as returned to the Bureau of Mines. There can be no doubt that the increase has materially contributed to higher costs in building operations. Advancing wages, and more expensive fuel and machinery have in this as in many other branches of industry forced the value of finished products to a higher—probably a permanently higher—level.

Year.	Price per M.	Year.	Price per M.
1901	$5 73	1905	$7.75
1902	6.41	1906	7.19
1903	6.78	1907	7.70
1904	7.15		

The statistics indicate a larger use of pressed brick than formerly, the production in 1907 having a value of $646,683, as against $337,795 in 1906. To some extent this better quality of brick has replaced the commoner variety. There is little doubt, too, that on the whole the brick made now are superior both in appearance and durability to those made years ago, greater skill and care being shown in their manufacture.

Other products of the kiln were paving brick, drain tile and sewer pipe, the aggregate value of which in 1907 was considerably in excess of 1906.

Product.	1906	1907
	$	$
Paving brick	45,000	73,270
Drain tile	252 500	250,122
Sewer pipe	279,620	435,088
Total	$577,120	$758,480

The production of building and crushed stone in 1907 had a value of $675,000, as against $660,000 in 1906.

Of lime the output was 2,650,000 bushels, valued at $418.700, as compared with 2,885,000 bushels worth $496,785 in 1906. The average value per bushel was 15.8 cents.

Portland Cement

Portland cement is now one of the most important of construction materials, and its manufacture is increasing in this Province with very considerable rapidity. Last year there were produced in Ontario 1,853,692 barrels worth $2,777,478, compared with 1,598,815 barrels worth $2,381,014 in 1906. The average price per barrel at the factory was $1.50, an increase of about 2 cents over 1906, when the price averaged $1.48 per barrel. The following Portland cement plants were in operation during the year: Raven Lake; Western Ontario, Atwood; Owen Sound, Shallow Lake; Belleville; Lakefield; Canadian, Marlbank; Sun, Owen Sound; National, Durham; Grey and Bruce, Owen Sound; Imperial, Owen Sound; Ontario, Blue Lake; Hanover. A trial run was made by the Superior Portland Cement Company, Orangeville, towards the close of the year, and the Colonial Portland Cement Company, Wiarton, also turned out a small quantity of cement, but most of the wages it paid during the year were for construction work, while the factories being erected by the Lehigh Portland Cement Company on the Bay of Quinte near Belleville, and the Ben Allen Portland Cement Company at Ben Allen, were still in course of construction on 31st December.

The business of making natural rock cement is nearly extinct in this Province, baving been crowded out by the manufacture of Portland. Last year only 7,239 barrels were made, a reduction even from the output of 1906, when it was 8,453 barrels, the smallest up to that date. In 1899 natural rock cement was made to the extent of 139,487 barrels. Nearly the whole production last year was by the Empire Cement and Lime Company of Queenston, successors to Messrs. I. Usher and Sons. The other manufacturers, Messrs. F. W. Schwendiman and Company, Hamilton, Estate of John Battle, Thorold, and the Toronto Lime Company, Limehouse, did little or nothing.

Table XI showed the progress of both branches of the cement industry since the time Portland cement began to be manufactured in Ontario:

Table XI.—Production of Cement, 1891 to 1907

Year.	Natural Rock.		Portland.		Total.	
	Bbl.	Value. $	Bbl.	Value. $	Bbl.	Value. $
1891	46,178	39,419	2,033	5,082	48,211	44,501
1892	54,155	38,580	20 247	47,417	74,402	85,997
1893	74,353	63,567	31,924	63,848	106,277	127,415
1894	55,323	48,774	30,580	61,060	85,903	109 834
1895	55,219	45,145	58,699	114,332	113,918	159,477
1896	60,705	44,100	77,760	138,230	138,465	182,330
1897	84,670	76,123	96,825	170,302	181,495	246,125
1898	91,528	74,222	153,348	302,096	244,876	376,318
1899	139,487	117,039	222,550	414,228	362,037	561,266
1900	125,428	99,991	306,726	598,021	432,151	698,015
1901	138,628	107,625	350,660	563,255	489,288	670,880
1902	77,300	50,795	522,899	916,221	609,199	967,016
1903	89,549	69,319	695,260	1,182,799	784,809	1,252,118
1904	85,000	65,250	880,871	1,239,971	965,871	1,305,221
1905	14,741	10,402	1,254,360	1,783,451	1,269,101	1,793,853
1906	8,453	6,000	1,598,815	2,381,014	1,607,268	2,387,014
1907	7,239	5,097	1,853,692	2,777,478	1,860,931	2 782,575
Totals	1,207,956	961,451	8,157,249	12,788,801	9,374,205	13,750,255

The maufacture of pottery from native clay has been in a declining condition for some years, and the production fell in value from $65,000 in 1906, to $54,585 in 1907. In 1898 the output was valued at $155,000, and in 1903 at $160,000. The causes of this apparent lack of prosperity are said to be the severe competition of foreign products,

and the absence of suitable deposits of clay for the manufacture of the higher classes of goods. At the present time the potteries of Ontario using clay of home origin confine their output largely to the cheaper sort of articles, such as flower pots, jardinieres, hanging baskets, etc. In view of the mainly glacial origin of the clays of southern Ontario, occurrence of beds of kaolin or residual clay deposits of a high degree of purity is perhaps scarcely to be expected, but further and more systematic search is required before it can be asserted they do not exist. Some of the kaolinic clays of the Hudson Bay slope occurring in association with the seams of lignite on the Abitibi, Soweska, Missanabie and other tributaries of the Moose river, are likely to prove available some day for making the better classes of pottery, if not of porcelain and chinaware.[4] This, however, will not be until they are brought within reach by the extension of railway facilities.

The production of building materials and clay goods provides employment for a very considerable quantity of labor, as the following figures for the year 1907 show:

Product.	Men employed.	Wages
	No.	$
Brick, common, and drain tile	2,850	1,015,000
" pressed and paving	508	284,881
Cement	1,259	701,493
Lime	415	155,000
Pottery	55	20,220
Sewer pipe	232	132,884
Stone	1,100	480,000
Total	6,419	2,789,478

Arsenic

Refined white arsenic to the extent of 348½ tons, worth $40,104, was produced last year. Most of it was recovered in treating ores from the Cobalt camp at the Canadian Copper Company's refining works, Copper Cliff, but a quantity was also obtained by the Deloro Mining and Reduction Company from material on hand derived from the mispickel ore of that locality. In Table I the total production of arsenic is given as 2,958 tons, which includes the tonnage of the refined article, but the figures of value are those only pertaining to the white arsenic manufactured in Ontario, since nothing, or next to nothing, was received by the mining companies for the arsenic contained in their shipments. White arsenic has many uses in the arts, based mainly upon its poisonous properties, and it is also largely employed in glass-making and as a pigment.

Corundum

The corundum mines of Ontario produced 2,683 tons of grain corundum last year, having a value of $242,608. The output was somewhat less than in 1906, when it was 2,914 tons, worth $262,448. The Canada Corundum Company and the Ashland Emery and Corundum Company are still the only concerns producing corundum. The mines and works of the former are at Craigmont, in the county of Renfrew, those of the latter at Burgess Mines, Hastings county.

The following figures show the production of corundum during the five years beginning with 1903:

Table XII.—Production of Corundum 1903 to 1907

Schedule.	1903	1904	1905	1906	1907
Corundum produced ... tons	1,119	1,665	1,681	2,914	2,683
Value of product ... $	87,600	150,645	152,464	262,448	242,608
Workmen ... No.	186	202	216	235	247
Wages paid ... $	106,332	139,548	109.128	160.354	168,333

[4] See Economic Resources of Moose River Basin, by J. M. Bell, Bur. Min. Rep., vol. xiii, pp. 159, *et seq.*

Feldspar

The feldspar quarries of Frontenac county were not operated so vigorously last year as in 1906, the production being 12,323 tons, worth $30,375, as compared with 20,373 tons, valued at $43,849. The Kingston Feldspar and Mining Company and the Verona Mining Company were the active operators last year. The product is shipped to New Jersey and Ohio for use in the manufacture of pottery and enamelled ware.

There has been a gradual but somewhat fluctuating development in the feldspar business, as the following figures for the last five years indicate:

Table XIII.—Production of Feldspar 1903 to 1907

Schedule.	1903	1904	1905	1906	1907
Feldspar raised..........tons	15,296	10,983	12,234	20,373	12,328
Value of product..........$	20,046	21,966	29,968	43,849	30,375
Workmen employed..........No.	51	34	52	89	71
Wages paid..........$	14,089	16,300	19,200	40,807	23,359

Iron Pyrites

The iron pyrites deposits of Ontario are now beginning to yield a considerable tonnage, which is partly manufactured into sulphuric acid in the Province and partly exported for similar uses to the United States. The Northland Mining Company, the Canadian Pyrites Company, the Lake Superior Corporation and the Nichols Chemical Company together raised and shipped 15,755 tons of pyrites during the year, valued at $51,842. The Northern Pyrites Company has for some time been developing an extensive deposit on Minnitakie lake, but will not be in a position to put its product on the market until the completion of the Fort William branch of the Grand Trunk Pacific railway. The sulphuric acid works erected by the Nichols Chemical Company at Sulphide, Hastings county, have been in successful operation since their completion last year. The ore is obtained largely from the company's own deposit, known as the Hungerford mine, close to the works, and partly also from other openings in the neighborhood. Sulphuric, nitric and mixed acids are made by the contact process, and are shipped in the company's tank cars to various parts of Ontario and Quebec, for such uses as refining petroleum, making dynamite, vulcanizing rubber, etc. A full account of the Iron Pyrites industry of Ontario was given by Mr. E. L. Fraleck, in the Sixteenth Report of the Bureau of Mines (1907), Part I.

Table XIV shows the growth of iron pyrites mining in the Province during the last five years:

Table XIV.—Production of Iron Pyrites 1903 to 1907

Schedule.	1903	1904	1905	1906	1907
Pyrites shipped..........tons	7,169	13,451	7,325	11,090	15,755
Value of do..........$	21,693	43,716	21,885	40,583	51,842
Workmen employed..........No.	39	60	68	128	137
Wages paid..........$	16,327	22,875	27,690	57,580	75,365

Mica

The production from the mica mines of the Province last year amounted to 456 tons of rough-cobbed material, valued at $82,929. In 1906 it was returned at 355 tons, worth $69,041. The chief producers were the Loughborough Mining Company, Kent Bros. and J. M. Stoness, J. P. Tett and Bros., and Dominion Improvement and

Development Company. In addition to these a quantity of mica raised in Ontario was purchased by trimming works at Ottawa, which is included in the total given above.

The production is practically all of the amber or phlogopite variety, and is used mostly for insulating purposes in the manufacture of electrical machinery. It is largely exported to the United States. Formerly, the larger sizes only of cut mica were marketable, but since the introduction of micanite, the smaller pieces can be utilized and now have a value as well. This has tended to an equalization of prices for mica, and has increased the proportion of saleable material to the gross output, since very much of the mica that comes to the surface is in fragments and small pieces.

Salt

The salt-producing area of Ontario is situated on the east shores of lakes Huron and St. Clair, where the limestones of the Onondaga formation contain salt beds of great aggregate thickness. For instance, a well sunk on lot 11, concession 11, in the township of Enniskillen, Lambton county, penetrated a total thickness of 705 feet of salt in going down from 1,210 to 2,015 feet in depth.[5] There were nine beds of salt in all, varying in thickness from 25 to 140 feet, two or three containing seams of dolomite, but most of them pure. There is unlimited scope here not only for the manufacture of salt itself, but also of caustic soda, bleaching powder and other chemicals requiring chloride of sodium as raw material.

The practice is to pump the brine, to form which it is in some cases necessary to force fresh water down the wells, and afterwards evaporate it. The Canadian Salt Company, Windsor, produces the greater part of the salt made in Ontario, other operators being the Empire Salt Company, Sarnia, the Western Salt Company, Mooretown, Gray, Young and Sparling, Wingham, Ontario People's Salt and Soda Company, Kincardine, Parkhill Salt Company, Parkhill, Exeter Salt Works Company, Exeter, and John Ransford, Clinton and Brussels. The quantity of salt reported made in 1907 was 62,806 tons, valued at $432,936, compared with 50,414 tons, worth $367,738 in 1906.

Statistics of production for five years beginning with 1903 are as given in the following table. Not much difference in the output is to be noted from year to year.

Table XV.—Production of Salt, 1903 to 1907.

Schedule.	1903.	1904.	1905.	1906.	1907.
Salt produced .... tons	58,274	55,877	60,415	50,414	62,806
Value of salt produced .... $	388,097	362,621	356,783	367,738	432,936
Workmen employed .... No.	208	183	148	151	194
Wages paid .... $	87,995	84,682	68,580	69,153	85,935

Petroleum

According to returns made to the Department of Trade and Commerce, Ottawa, for bounty purposes, the yield of crude petroleum from Ontario was 27,621,851 Imperial gallons in 1907, as compared with 19,928,322 Imperial gallons in 1906,—a very decided increase, and being in fact, the largest production since 1895, when it was upwards of 33 million Imperial gallons. The value of the output of 1907 was $1,049,631, exclusive of the bounty of 1½ cents per gallon paid by the Government of Canada on domestic crude, as against $761,546 in 1906. The average price per barrel was almost precisely the same in 1907 as in 1906, viz., a little over $1.33, plus the government bounty. Crude was quoted at $1.30 per barrel at the beginning of the year, rose to $1.32 in February, and to $1.34 in March, at which figure it remained until 31st December.

[5] See Rep. Bur. Min., Vol. XIV., Part I, p. 113.

The new Tilbury district in Kent county, including the township of Raleigh, contributed about 44 per cent. of the whole product of crude last year, and yielded considerably more than the united output of the Petrolea and Oil Springs fields. The following estimate of the production of the several fields or pools is kindly furnished by the Imperial Oil Company of Sarnia:

	Bbls.
Dutton	14,698
Leamington (Staples and Comber	16,210
Bothwell	40,556
Richardson (Chatham)	941
Thamesville	1,139
Moore township	32,720
Oil Springs	55,813
Merlin (E. Tilbury and Raleigh)	344,358
Coatsworth (Romney)	49,783
Petrolea (including all districts not enumerated above)	206,285
Total	762,503

At 35 Imperial gallons per barrel, it will be observed, this estimate falls short of the quantity on which bounty was claimed and paid by 934.246 Imperial gallons, or 26,692 barrels. The discrepancy is not large, but it has been thought best to present in the schedules the official figures of the Department of Trade and Commerce. The importance of the Merlin or East Tilbury field lies not only in the large addition it has made to the production of crude petroleum, but also in the hope which it holds out of other reservoirs yet being found in the more deeply seated limestone formations of the southwestern peninsula.

The petroleum refineries, of which there are two, the Imperial Oil Company's at Sarnia, and the Canadian Oil Refining Company's at Petrolea, together distilled 34,961,706 Imperial gallons of crude petroleum, which is 7,339,855 gallons more than the entire product of the wells of Ontario for the year. As all of the domestic crude product does not find its way to the refineries, a considerable proportion being used for gas-making and other purposes, it is evident that the requirements of the home market for petroleum products is not being met by the supply of native crude, notwithstanding the recent increase in the latter.

In Table XVI are presented the statistics pertaining to the petroleum refining industry of the Province for the last five years:

Table XVI.—Petroleum and Petroleum Products, 1903 to 1907.

Schedule.		1903.	1904.	1905	1906.	1907.
Crude produced	Imp. gal.	16,640,333	17,237,220	22,131,658	19,928,322	27,621,851
Crude distilled	"	14,464,248	22,805,109	33,821,998	36,134,349	34,961,706
Value crude produced	$	1,024,597	904,437	898,545	761,546	1,019,631
Value distilled products	"	1,451,756	1,670,805	2,196,678	2,506,177	2,568,464
Illuminating oil	Imp. gal.	7,096,073	11,461,435	16,133,588	16,125,450	18,319,233
Lubricating oil	"	2,611,313	2,683,281	3,402,977	4,351,818	3,931,767
Benzine and naphtha	"	832,153	1,488,503	2,827,971	3,497,954	1,132,239
Gas and fuel oils and tar	"	1,968,172	1,962,752	5,788,351	5,961,834	5,632,608
Paraffin wax and candles	lb.	2,673,806	2,272,511	4,077,610	5,011,467	5,132,394
Workmen employed	No.	291	406	469	496	435
Wages paid	$	165,700	229,955	280,701	308,986	265,316

Natural Gas

The production of natural gas in Ontario has undergone a rapid and steady increase of late years, the value of the output in 1907 being $756,174; in 1906 it was $533,446; in 1905 $316,476; in 1904 $253,324; in 1903 $196,535; and in 1902 $199,238. This increase is due, as in the case of petroleum, to the opening up of new fields.

The Haldimand field is now producing almost as much gas as the Welland field, which for a number of years has been yielding freely for the supply of Buffalo, N.Y., and a number of towns and villages on the Canadian side of the border. Gas is being

sent from the Haldimand district to Hamilton, Brantford, Galt and other places within reach, the citizens of which are thus enabled to avail themselves of this ideal fuel for domestic purposes.

The Welland field in 1907 produced 46 per cent. of the total value of the gas output, the Haldimand field 44 per cent., and the counties of Kent and Essex 10 per cent. In the Welland field the Provincial Natural Gas and Fuel Company is the largest producer, but the United Gas Companies of St. Catharines, and the Mutual Natural Gas Company of Port Colborne, also raise considerable quantities of gas for local supply. The Dominion Natural Gas Company is the principal operator in the Haldimand field, and furnishes practically all the gas that leaves the field for the cities and towns above referred to.

Following are details of the production of natural gas for the five years ending 1907:

Table XVII.—Natural Gas Production 1903 to 1907

Schedule.		1903.	1904.	1905.	1906.	1907.
Value gas produced	$	196,535	253,324	316,476	533,446	746,499
Producing wells	No.	210	176	273	332	582
Producing wells sunk	"	20	36	58	77	161
Non-producing wells sunk	"	12	13	5	14	35
Delivery pipe	miles	312	231	461	550	810
Workmen employed	No.	138	98	130	108	181
Wages paid	$	79,945	53,674	88,865	64,968	110,832

Minor Products

Table I gives particulars regarding the output of minor products, including calcium carbide, graphite, gypsum, peat fuel, quartz and talc, which continue to be produced at about the same rate from year to year.

The most important in point of value are calcium carbide, of which $173,763 worth was shipped from the works of the two companies manufacturing this material, namely, the Ottawa Carbide Company of Ottawa, and the Willson Carbide Company of Merritton; and quartz, the production of which increased from 48,376 tons, worth $65,765 in 1906, to 56,585 tons worth $124,148 in 1907. The latter is used mainly as a flux and for furnace linings in smelting the nickel-copper ores of the Sudbury district. Part of the rock included under the heading "quartz" was really quartzite.

Mining Revenue

The year 1907 was an exceptional one in point of mining revenue. Receipts from the sale of mining lands surpassed all former records, fees from the sale of miner's licenses and the recording of claims were unusually heavy, and the new sources of revenue provided by the Supplementary Revenue Act 1907 and in other ways, helped to swell the total. The whole income was $1,731,720.72, which contrasts with $250,121, the receipts in 1906. The items are as follows:

Sales of mining land	$1,184,719 06
Leases " "	21,563.16
Miner's licenses, recording fees, etc.	272,397.13
Royalties	207,945.06
Supplementary Revenue Act, 1907	43 453.35
Assay Office, Belleville	1,642.96
Total	$1,731,720.72

It will be seen that mining lands disposed of yielded $1,206,282.22. The larger part of this sum represents the purchase money of those parts of the beds of Cobalt and Kerr lakes which were sold at public tender, the former in December, 1906, and the

latter in January, 1907. As ten per cent. only of the purchase price was required to be paid along with the tender, ninety per cent. of the price of Cobalt lake fell within the receipts of 1907. Cobalt lake brought $1,085,000, and Kerr lake $178,500.

Apart from these exceptional transactions, sales and leases of mining lands produced less than usual, the tendency of the amended mining law being to confine the purchase of mining lands to those parcels which development work has shown to contain at least some promise of mineral. Under the old law, which permitted mining lands to be bought before any development wark was done upon them to test their value, the inevitable result of a rich strike on Crown land was the immediate purchase or lease of numerous locations in the neighborhood of the find. In many cases lands so purchased were found to have no value, or were never proven, and either reverted to the Crown upon failure to comply with the necessary conditions, or remained dormant in the hands of their owners. Under the present law, the development work prescribed by the Act must be done before the grant is made by the Crown. One effect of this is that if the claim-holder finds on testing his discovery that it is not likely to prove valuable, he can and does abandon it without expending anything further upon it. This reduces the sales of mining land, both in number and also in area, since the Act limits claims to 40 acres in size, whereas formerly a claim or location might contain as much as 320 acres. Even in cases where the land is eventually purchased, the sale may be postponed, since the Act allows three years and three months in which to perform the necessary assessment work.

The patents and leases of mining lands granted during the year were as follows:

District.	Sales.			Leases.			Totals.		
	No.	Ac.	Amount $	No.	Ac.	Amount. $	No.	Ac.	Amount. $
Rainy River	......	....	....	16	2,303	2,303	16	2,303	2,303
Thunder Bay	1	58	145	5	1,178	1,178	6	1,236	1,323
Algoma	13	1,069	2,528	8	1,300	1,194	21	2,369	3,722
Elsewhere	243	8,183	1,286,033	34	3,413	3,413	277	11,596	1,289,446
Totals	257	9,310	1,288,706	63	8,194	8,088	320	17,504	1,296,794

It will be observed that the total in the above table differs slightly from the sum of the items "Sales of mining land" and "Leases of mining land" in the table immediately preceding. The reason for this difference is that the latter table is a statement of the moneys actually received during the year, in other words, the collections during the twelve months, while the former table shows the amounts paid in for lands patented or leased within the year, irrespective of the date of payment. Lands paid for late in December may not be actually patented until early in January; and frequently moneys remain for some time in the Department at the credit of an applicant awaiting proof of title, completion of survey, or for other like reason.

Miners' Licenses and Recording Fees

The item "Licenses and recording fees" on account of which $272,397.13 was received in 1907, was derived in nearly equal proportion from miner's licenses and recording fees, the former yielding $137,768.40, and the latter $131,628.73. It is evident that this source of receipts must be a fluctuating one, and will vary according to the degree of activity exhibited in prospecting and staking out mining claims. In periods of excitement following upon discovery of rich deposits of mineral, there will be an influx of prospectors, more licenses will be sold and more claims staked out and recorded. In more normal times, when prospecting and the taking up of claims is less active, there will be a falling off in this branch of mining revenue. By amendment made to the Mines Act during the session of 1907, the fee for a miner's license was reduced from $10 to

$5, but the Act was not passed until 20th April. Miner's licenses expire on 31st March of every year, and must be renewed if there are any unpatented mining claims depending upon them. Such renewals made before 20th April, 1907, cost $10 each, so that the full benefit of the reduction was not realized by the prospecting community until the present year. A further amendment made in 1908 rendered it unnecessary for a mining company working the minerals on patented lands to hold a miner's license for that purpose only. For these several reasons, the receipts from miners' licenses are not likely to be as great in 1908 as in 1907.

Royalties

Royalties as an item of mining revenue first appeared in the records of the Department in 1906, when $15,000 was received from the O'Brien silver mine. The receipts in 1907 were $207,945.06, and as before were derived wholly from the O'Brien mine, under the agreement between the owners of that mine, and the Government, dated 11th December, 1906, by which the latter received 25 per cent. of the value of the ore obtained from the mine, at the pit's mouth. As mentioned above, one other producing mine, the Crown Reserve, pays a royalty to the Crown, the rate in this case being 10 per cent. Up to the end of 1907 no shipments had been made by the Crown Reserve, and consequently no royalty paid. It will undoubtedly figure in the receipts for 1908.

Supplementary Revenue

The Supplementary Revenue Act, 1907, imposed (1) a tax of three per cent. on the profits of mines in Ontario in excess of $10,000 per annum, (2) a tax of two cents per acre on all patented and leased mining lands in unorganized districts, and (3) a tax of two cents per thousand cubic feet on natural gas, 90 per cent. of which is remitted when the gas is consumed in the Province. The total receipts under the Act during 1907 were $43,453.35. Following are the details:

Profit tax	$26,922.00
Gas tax	11,527.47
Acreage tax	5,003.88
Total	$43,453.35

Owing to the fact that the profit and gas taxes were not payable for 1907 until 1st December, the full amount payable under these headings was not received before the close of the year, considerable amounts being paid in during the early part of 1908, which will appear in the accounts of the latter year.

The collection of the revenue under the Supplementary Revenue Act, 1907, is largely under the charge of the Mine Assessor, whose duties are prescribed by the Act. Mr. George R. Mickle, M.E., formerly professor of Mining Engineering in the School of Practical Science, Toronto, was appointed to the position of Mine Assessor on 10th May, 1907. Mr. Mickle having practised his profession in the nickel-copper region of Sudbury, and having acted as chief inspector of mining claims in the Cobalt district, was thoroughly familiar with the mining industry of the Province, and the conditions under which it is carried on. One happy result of Mr. Mickle's operations in the natural gas field has been to practically put an end to the almost criminal waste of gas, which, particularly in the Kent county field, accompanied search for petroleum. Mr. Mickle supplies the following notes regarding the operation of the Supplementary Revenue Act, 1907, so far:

The total amount collected under the Act for the year 1907, was $84,396.44, which should be distributed as follows:

(1) Profit tax on working mines	$65,155.38
(2) Tax on natural gas	13,513.18
(3) Acreage tax up to April 1908	5,727.88
Total	$84,396.44

As the tax for 1907 was not due till 1st December, and the whole Act was new, there were some cases where payment was not made until early in 1908, and consequently these amounts do not appear in the accounts for 1907. There were no appeals.

In explanation of the various headings under which the amount collected is given it may be stated:

(1) The sum allotted to the profit tax is what accrued to the Province from the operation of ten companies, some of them operating several mines. The greater part was from the silver mines of Cobalt. Outside of the silver, the copper-nickel mines of Sudbury contributed the next in amount. As iron ores smelted in Canada are exempt from the profit tax, there was only a small amount levied from one company, which exported a portion of its product. In addition to these, one company operating mica mines paid a tax. The number of companies that will contribute in 1908 will be greater.

(2) Regarding the tax on natural gas, the conditions of production are totally different from those obtaining in mines working a solid mineral product, in that while with the mines the owner of a certain area of surface of mineral land has only the right to mine and remove ore within the boundaries of that area extended downwards vertically indefinitely, in the case of gas the holder of a certain area on the surface may by sinking a well draw gas from a territory away beyond his surface holdings extended vertically downwards. All or a number may be drawing from a common supply, and therefore a fixed amount per unit produced seems the natural mode of taxation. There are a number of small producers, twenty-six companies or individuals in all contributing. The Act provides for two cents per thousand feet, with a rebate of 90 per cent. provided the gas is used in Canada; this is equivalent to one-fifth of a cent per thousand feet. Gas exported or allowed to go to waste is subject to the two-cent tax. The effect of the heavy tax on gas exported will be a rapid diminution in the amount piped out of the country, and it has already had a very great influence in this direction. There will be some revenue from gas wasted in 1907; some of the operators displayed an incredible indifference to waste of gas. In September last the daily loss, measured from ten wells in the Chatham field, amounted to about 11,000,000 cubic feet, or about $2,000 per day at average prices paid. The imposition of the tax was sufficient to shut off the waste of the worst of these wells immediately. With the amendments to the Act made during the session of 1908, it will be possible to handle more effectively cases where the owners neglect to act promptly, and, as long as the provisions are enforced, any serious waste cannot occur. Of the amount collected under the gas tax in 1907, $3,575.68 was on gas used in Canada, and the balance on gas exported. The prospect of any considerable revenue from the gas is very small, in spite of the fact that the production is increasing and the gas territory is being extended. The exportation is dropping, and as waste will be eliminated the revenue will decline. From the point of view of the producer and consumer in this country, this result is highly beneficial.

(3) No close estimate can be given of the amount that will probably be collected under acreage tax, as it is impossible to say how many will allow their lands to be forfeited It will also take some time before the owners of the taxable lands become aware of the Act. It is noticeable that a greater percentage of those accustomed to pay under the Algoma land tax have settled than of those owning lands not coming under that tax. The Supplementary Revenue Act provides for a tax only on lands where there is no municipal organization, and which consequently would otherwise have no taxation. The greater part of the area subject to this Provincial tax is in those parts of the Province where mining lands were alienated from the Crown at a time when large blocks were granted, and also where the population is very small, and there are consequently few organized townships. Thunder Bay District (Judicial Division) contains 421,526 acres of lands disposed of as mining lands, and Rainy River District 151,082 acres subject to this tax. The other districts do not contain so much, so that the total amount will be well under a million acres. The revenue that will accrue to the Province from this source will probably be only somewhere in the vicinity of $10,000, but it will no doubt be of service in keeping titles clear.

The remaining item of mining receipts, namely, $1,642.96 from the Provincial Assay Office, at Belleville, represents the amount of fees paid in by prospectors and others for assays and analyses of mineral samples. The receipts from the Belleville Assay Office based, as they are, on a very moderate scale of charges, go a long way towards defraying the cost of its maintenance.

Mining Companies

There were incorporated under the laws of Ontario last year 321 joint stock companies, in connection with the mineral industry, with a total authorized capital of $319,876,000. The list is given below. A perusal of it will show that the fever for dealing and speculating in the shares of silver mining companies which followed upon the discoveries at Cobalt and Montreal river, was responsible for the formation of a large proportion of these companies, many of which were of the veriest "bubble" kind. The gold finds at Larder Lake contribute their quota, and so also do the gas and oil strikes in the southwestern peninsula. Licenses to do business in Ontario were granted to fifteen companies of foreign or extra-Provincial incorporation, having a total capital of upwards of $5,815,000. There was an altogether unusual activity in the formation of mining companies last year, as will be seen from a comparison with 1906, when the number incorporated was 263, with a share capital of $184,677,000, and still more plainly from the figures for 1905, when the incorporations were 99, with a capital of $27,509,000.

Mining Companies Incorporated in 1907

Name of Company.	Head Office.	Date of Incorporation.	Capital Stock.
Adelaide Mining Company, Limited	Napanee	October 21, 1907	$1,000,000
Aganni Cobalt Mines Limited	London	August 29	600,000
Airgiod Cobalt Mining Company, Limited	Ottawa	January 18	2,000,000
Algoma Lead, Limited	Port Arthur	July 31	1,500,000
Algonquin Larder Lake Mining Company, Limited	Toronto	May 15	2,500,000
American Consolidated Mining Company, Limited	Toronto	March 15	500,000
Anglo-Canadian Cobalt Mining Company, Limited	Toronto	March 28	1,100,000
Argyle Silver Mining Company, Limited	Toronto	February 8	500,000
A. W. Jacobs Cobalt Mines Limited	Ottawa	May 24	1,500,000
Barnard's Point Gold Mining Company of Larder Lake, Limited	Hamilton	February 8	1,000,000
Beamsville Larder Lake Prospecting Company, Limited	Beamsville	April 8	100,000
Beaver Consolidated Mines, Limited	Toronto	February 25	1,500,000
Beaver Superior Silver Mines, Limited	Toronto	May 31	3,000,000
Bedford Mica Company, Limited	Toronto	December 11	100,000
Big 4 Larder Lake Mining Company, Limited	Toronto	February 25	1,000,000
Big Pete Canadian Mines, Limited	New Liskeard	November 1	2,000,000
Blue Bell Gold Mines, Limited	Toronto	April 8	5,000,000
Bonanza Consolidated Mines, Limited	Toronto	July 10	1,000,000
Bonanza Larder Lake Mining Company, Limited	Haileybury	February 22	1,000,000
British-Canadian Smelters, Limited	Toronto	June 12	400,000
Buffalo Larder Gold Mines, Limited	Toronto	May 31	2,000,000
Canada Brick Fields, Limited	London	October 11r	100,000
Canada Consolidated Cobalt Syndicate, Limited	Toronto	February 21	1,000,000
Canada International Gas Company, Limited	Toronto	September 7	5,000,000
Canada Mexico Development Company, Limited	Toronto	December 4	200,000
Canada Southern Oil & Gas Company, Limited	Tilbury	December 27	100,000
Canadian Bessemer Ores, Limited	Toronto	May 22	100,000
Canadian Central Mines, Limited	Toronto	January 23	1,000,000
Canadian Mines Syndicate, Limited	Ottawa	January 16	100,000
Canadian Pacific Cobalt Development Company, Limited	Ottawa	April 8	3,500,000
Canuck Silver Mines, Cobalt, Limited	Toronto	April 17	1,000,000
Carleton Cobalt Silver Mining Company, Limited	Ottawa	January 23	1,000,000
Clark Cobalt Mining Company, Limited	Toronto	August 29	3,000,000
Cobalt and James Mines, Limited	Toronto	May 24	1,000,000
Cobalt Blue Silver Mining Company, Limited	Toronto	March 1	1,000,000
Cobalt Combine Silver Mines, Limited	Toronto	May 15	1,000,000
Cobalt Concentrators, Limited	Toronto	February 25	500,000
Cobalt Confederated Mines, Limited	Cobalt	May 31	3,000,000
Cobalt Crystal Silver Mines, Limited	Toronto	February 28	50,000
Cobalt Eagle Silver Mines, Limited	Ottawa	January 26	1,000,000
Cobalt Eldorado Mines Company, Limited	Toronto	May 1	2,000,000
Cobalt Gem Mining Company, Limited	Toronto	January 11	1,000,000
Cobalt Lorrain Mining & Development Company, Limited	Cobalt	April 10	1,500,000
Cobalt Magnet Mines, Limited	Toronto	March 22	600,000
Cobalt North Star Silver Mining Company, Limited	Bridgeburg	February 8	10,000
Cobalt Silver Bell Mines, Limited	Cobalt	May 8	800,000
Cobalt Silver Fountain Mines, Limited	Toronto	July 12	500,000
Cobalt Superior Mining Corporation, Limited	Toronto	October 17	1,000,000
Cobalt Syndicate of Montreal, Limited	Toronto	March 25	600,000
Cochrane Cobalt Mining Company, Limited	Toronto	March 22	1,000,000
Coleman-Bucke Silver Mining Company, Limited	Ottawa	May 22	1,000,000
Columbia Cobalt Development Company, Limited	Cobalt	July 8	500,000
Combined Goldfields, Limited	Toronto	May 10	3,000,000
Commercial Travellers Larder Lake Gold Mining Company, Limited	New Liskeard	March 6	500,000

Mining Companies Incorporated, 1907—Continued

Name of Company.	Head Office.	Date of Incorporation.	Capital Stock.
Commonwealth Mines of Cobalt, Limited	Toronto	January 28	$5,000,000
Confederation Mines, Limited	Hamilton	March 8	250,000
Conference Exploration Company, Limited	Cobalt	June 19	500,000
Crawford Mining Company, Limited	Toronto	October 11	600,000
Credit Valley Brick Company, Limited	Toronto	November 20	50,000
Cross Lake Silver Mining Company, Limited	Cobalt	June 28	1,000,000
Crown Oil Refining Company, Limited	Hamilton	June 26	40,000
Cullen Cobalt Mines, Limited	Toronto	February 28	1,000,060
Culver Silver Cobalt Mines, Limited	Toronto	February 18	1,000,000
Deloro Mining & Reduction Company, Limited	Toronto	February 13	100,000
Dominion Bessemer Ore Company, Limited	Port Arthur	July 19	7,500,000
Dominion Exploration & Development Company, Limited	Toronto	May 10	1,000,000
Dominion Oil Company, Limited	Hamilton	August 15	100,000
Dominion Smelters, Limited	Sault Ste. Marie	January 23	1,000,000
Dr. Reddick Larder Lake Mines, Limited	Ottawa	February 6	2,000,000
Duchess Silver Mining Company, Limited	Toronto	January 16	75,000
East Bay Larder Lake Gold Mines, Limited	Toronto	May 10	1,000,000
Eastern & Cobalt Mining Company, Limited	Cobalt	May 8	1,000,000
Elk Lake Prospecting & Development Company, Limited	Toronto	March 20	250,000
Elk Lake Silver Mines, Limited	Haileybury	April 8	100,000
Emerald Development Company, Limited	Sudbury	February 18	150,000
Empire Cobalt Mines, Limited	Cobalt	March 27	3,000,000
England's Premier Cobalt Mining Company, Limited	Toronto	March 8	1,100 000
Erie Portland Cement Company, Limited	Toronto	March 6	1,000,000
Floyd Silver Mines, Limited	Toronto	March 13	2,000,000
Forest City Gold Mining Company, Limited	Toronto	May 15	1,000,000
Glengarry Cobalt Mines, Limited	Haileybury	September 13	600,000
Gold Consols, Limited	Toronto	October 25	1,500,000
Gold Mint Mining Company of Larder Lake, Limited	Toronto	June 12	1,000,000
Golden Empire Mines Company of Larder Lake, Limited	Powassan	June 6	1,000,000
Golden Horn (Larder Lake) Mines, Limited	Toronto	February 13	500,000
Good Hope Mines, Limited	Toronto	April 26	3,000,000
Gould Consolidated Mines, Limited	Ottawa	November 27	2,000,000
Grand Manitoulin Oil Company, Limited	Toronto	August 23	500,000
Greater Canada Mining Company, Limited	Toronto	April 23	2,500,000
Green Robin Gold Mines, Limited	Toronto	June 26	1,500,000
Haileybury Brick & Tile Company, Limited	Haileybury	September 3	50,000
Haileybury-Bucke Cobalt Company, Limited	Toronto	April 17	40,000
Hall Mark Silver Mines, Cobalt, Limited	Toronto	June 26	300,000
Hanson Consolidated Silver Mines, Limited	Toronto	May 24	1,500,000
Hardwood Glen Mining Company, Limited	Toronto	February 6	60,000
Harris Maxwell Larder Lake Gold Mining Company, Limited	Toronto	January 26	500,000
Hiawatha Cobalt Silver Mining Company, Limited	Ottawa	February 28	1,000,000
Higbee Mines, Limited	Toronto	April 17	40,000
Holden Silver Mining Company, Limited	Cobalt	November 6	650,000
Imperial Consolidated Mining Company, Limited	Toronto	April 23	1,500,000
Indiana Cobalt Silver Mining Company, Limited	Toronto	November 13	250,000
Industrial Natural Gas Company, Limited	Welland	November 27	40,000
Island Oil and Gas Company, Limited	Manitowaning	January 18	100,000
James Bay Gold Mining and Development Company, Limited	Toronto	July 19	2,000,000
James Mines, Limited	Toronto	February 28	25,000
James Proprietary Mines, Limited	Toronto	June 21	250,000
Johnson Mines, Limited	Toronto	August 11	1,000,000
Jumbo Cobalt Silver Mines, Limited	Toronto	February 15	1,000,000
Kerr Lake Crown Reserve, Limited	Toronto	January 16	2,000,000
Keystone Cobalt Mining Company, Limited	Toronto	January 1	500,000
Keystone Lorrain Mining Company, Limited	Haileybury	July 31	1,000,000
King Solomon Larder Lake Gold Mining Company, Limited	New Liskeard	April 23	1,000,000
Kismet Mines, Limited	Pittsburg, Pa	January 23	560,000
Lake George Cobalt Silver Mining Company, Limited	Toronto	March 6	1,500,000
Laplata Cobalt Mines Company, Limited	Toronto	April 3	1,000,000
Larder Gold Fields, Limited	Toronto	April 12	1,500,000
Larder Gold Reefs Company, Limited	Ottawa	October 2	40,000
Larder Lake Consolidated Gold Mines, Limited	Toronto	January 23	1,000,000
Larder Lake Exploration and Development Company, Limited	Haileybury	January 16	500,000
La Rose Mines, Limited	Toronto	April 13	6,000,000
Lehigh Cobalt Silver Mines, Limited	Toronto	April 17	1,000,000
Le Roi Larder Lake Mines, Limited	Haileybury	March 15	1,000,000
Little Larder Lake Gold Mining Company, Limited	Haileybury	February 15	100,000
London Cobalt Mining Corporation, Limited	Toronto	January 4	2,000,000
Long Lake Gold Mining Company, Limited	Welland	October 25	1,000,000
Lucky Boys Gold Mines, Limited	Toronto	April 16	3,000,000
Manchester Cobalt Mines, Limited	Toronto	February 28	450,000
Martin Larder Gold Mines, Limited	Toronto	May 10	1,000,000
Midas Mines, Limited	Toronto	August 2	1,000,000
Milburn Cobalt Silver Mines, Limited	Peterborough	March 8	200,000
Mines, Limited	Toronto	January 4	40,000
Mississippi Cobalt Silver Mining Company, Limited	Carleton Place	April 23	1,000,000
Mohawk Cobalt Silver Mines, Limited	Toronto	April 16	1,500,000
Monessen Cobalt Mining Company, Limited	Cobalt	August 29	200,000

Mining Companies Incorporated, 1907—Continued

Name of Company.	Head Office.	Date of Incorporation.	Capital Stock.
Monitor Cobalt Prospecting and Development Company, Limited	Toronto	April 23	500,000
Montreal Gold and Silver Mining Company, Limited	Cobalt	May 31	10,000
Montreal River International Silver Mines, Limited	Toronto	May 17	1,000,000
Montreal River Mines, Limited	Toronto	June 28	30,000
Moose Horn Mines, Limited	Toronto	August 21	2,000,000
Munroe Prospecting and Developing Company, Limited	Cobalt	May 17	200,000
Murphy Mines, Limited	Haileybury	May 22	1,000,000
New Ontario Exploration Company, Limited	Sault Ste. Marie	January 16	100,000
New York Ontario Exploration Company, Limited	Bracebridge	May 15	1,000,000
North Star Larder Lake Mining Company, Limited	Toronto	April 17	1,000,000
North West Bay (Larder Lake) Mining Company, Limited	Toronto	February 13	500,000
Northern Consolidated Cobalt Mines, Limited	Toronto	April 23	1,500,000
Northern Gold and Silver Mining Company, Limited	Ottawa	April 3	1,000,000
Northern Larder Lake Mining Co., Limited	Haileybury	February 13	1,000,000
Onaping Iron Ore Company, Limited	Toronto	June 26	200,000
Ontario Copper Company, Limited	Toronto	May 15	3,000,000
Ore Reduction Company, Limited	Toronto	March 8	250,000
Orok (Dr.) Larder Mines, Limited	Haileybury	May 3	750,000
Power City Cobalt Mines Company, Limited	Toronto	September 7	1,000,000
Premier Cobalt Mines, Limited	Toronto	December 19, 1906.	2,000,000
Pride of Cobalt Silver Mines, Limited	Toronto	August 2, 1907	5,000,000
Prospect Developing and Mining Company, Limited	Cobalt	May 22	1,000 000
Provincial Mines, Limited	Toronto	April 8	50,000
Queen Alexandra Mining Company, Limited	Toronto	March 22	40,000
Queen of Sheba Gold Mines, Limited	Sudbury	February 18	1,000,000
Rabbit Mountain Mines, Limited	Toronto	March 6	3,000,000
Ragged Falls Mining Company, Limited	Toronto	July 19	1,000,000
Railway Reserves Mines, Limited	Ottawa	January 4	1,000,000
Red Rose Mining Company, Limited	Toronto	March 6	600,000
St. Lawrence-Cobalt Mining Company, Limited	Bridgeburg	February 13	40,000
Searchlight Larder Lake Mines, Limited	New Liskeard	May 31	3,000,000
Shamrock Silver Company, Limited	Toronto	March 1	1,000,000
Silver Belt Cobalt Mining Company, Limited	Toronto	April 10	1,500,000
Silver Circle Mining Company, Limited	Toronto	May 24	500,000
Silver Cross Cobalt Mining Company, Limited	Ottawa	March 27	500,000
Silver Pick Cobalt Mining Company, Limited	Ottawa	February 13	1,000,000
Silver Spade Mining Company, Limited	Toronto	December 2	500,000
Silver Square Mining Company, Limited	Cobalt	February 8	50,000
Smaltite Silver Mining Company, Limited	Toronto	April 12	1,000,000
Societe Electrometallurgique Canadien, Limited	Toronto	February 1	40,000
Spears Mining Corporation, Limited	Toronto	September 17	50,000
Sterling Gas Company, Limited	Port Colborne	May 8	40,000
Sutton Bay Cobalt Silver Mining Company, Limited	Haileybury	January 23	50,000
Tecumseh and Walkerville Oil and Gas Company, Limited	Walkerville	July 8	40,000
Tehkummah Oil Company, Limited	Toronto	April 10	40,000
The American Cobalt Mines, Limited	Toronto	February 15	1,000,000
The Arsenic Lake Silver Mining Company, Limited	North Bay	July 8	300,000
The Ash Grove Mining Company, Limited	Englehart	October 4	500,000
The Auld Silver Mines, Limited	North Bay	May 8	500,000
The Bay Lake Mining Company, Limited	Ottawa	June 21	1,000,000
The Big Hundred Larder Gold Company, Limited	New Liskeard	April 3	2,500,000
The Big 3 Silver Mining Company, Limited	Toronto	March 8	2,000,000
The Bloom Lake Mines Company, Limited	Sandwich	November 6	100,000
The British Dominion Mines, Limited	Toronto	May 10	1,000,000
The Canadian Smelting and Refining Company, Limited	Toronto	April 12	1,000,000
The Canadian Smelting and Refining Company, Limited	Toronto	September 13	2,500,000
The Carleton Gold and Silver Mining Company, Limited	New Liskeard	May 10	1,000,000
The Casey Mountain Cobalt Mining and Developing Company, Limited	Haileybury	January 4	250,000
The Champion Mines Company, Limited	New Liskeard	April 19	1,000,000
The Chaudiere Mines, Limited	Ottawa	March 27	1,500,000
The Chesterville Larder Lake Gold Mining Company, Limited	Chesterville	March 20	1,000,000
The Cleopatra Mining Company, Limited	Ottawa	February 28	2,000,000
The Cobalt and Blanche River Silver Mining Company, Limited	Ottawa	February 1	500,000
The Cobalt Certainty Silver Mines, Limited	Toronto	March 13	2,000,000
The Cobalt Mutual Mines Company, Limited	Haileybury	January 4	100,000
The Cobalt Raven Mining Company, Limited	Ottawa	April 16	600,000
The Cobalt Shippers, Limited	Cobalt	October 21	40,000
The Cobalt Silver and Gold Claims Company, Limited	Cobalt	May 22	40,000
The Cobalt Silver-Gold Pool Mining Company, Limited	Cobalt	March 20	100,000
The Cobalt Silver Mountain Mining Company, Limited	Ottawa	January 26	1,000,000
The Cobalt Silver Stone Mining Company, Limited	Ottawa	February 20	500,000
The Cobalt Silver Wedge Mines, Limited	Cobalt	June 12	1,000,000
The Cobden Copper Company, Limited	Sault Ste. Marie	February 15	500,000
The Coleman and Larder Lake Gold and Silver Mining Company, Limited	Toronto	January 26	1,000,000
The Cooper Tilbury Oil and Gas Company, Limited	London	July 10	100,000
The Crown Gas and Oil Company, Limited	Ottawa	July 8	250,000
The Crown Gypsum Company, Limited	Cayuga	November 22	100,000
The Dominion Larder Gold Mines, Limited	Cobalt	April 3	3,000,000
The Dominion Mining Company, Limited	Ottawa	September 3	150,000

Mining Companies Incorporated, 1907—Continued

Name of Company.	Head Office.	Date of incorporation.	Capital. $
The Dowker Brick Company, Limited	Fort Frances	March 6	40,000
The Electrical Ore Finding Company, Limited	Toronto	October 21	1,000,000
The Elgin Cobalt Mining Development Company, Limited	St. Thomas	June 6	200,000
The Elk Lake Cobalt Silver Mining Company, Limited	North Bay	March 6	1,000,000
The Elk Lake Mining and Prospecting Company, Limited	Ottawa	July 8	1,000,500
The Empire Larder Lake Gold Mines, Limited	Toronto	May 3	1,000,000
The Empress Tilbury Oil and Gas Company, Limited	Chatham	April 4	150,000
The Enterprise Corporation Limited	Hamilton	January 4	500,000
The Federal Oil Company, Limited	Toronto	March 13	200,000
The Georgian Bay Oil Company, Limited	Fort Erie	January 25	1,000,000
The Gilmour Mining Company, Limited	Belleville	September 7	300,000
The Gold Belt Mining and Development Company, Limited	Ottawa	March 25	1,250,000
The Gold Horse Shoe and Larder Lakes Mining Company, Limited	Ottawa	August 14	1,500,000
The Golden Peak Larder Lake Exploration and Mining Company, Limited	Toronto	March 22	250,000
The Gray Hadley Spelter Company, Limited	Kingston	June 14	500,000
The Great Northern Oil Company, Limited	Sault Ste. Marie	January 31	500,000
The Haileybury Silver Mining Company, Limited	Haileybury	February 20	50,000
The Haileybury Townsite Mining Company, Limited	Sudbury	March 15	750,000
The Harwich Oil and Gas Company, Limited	Chatham	November 8	100,000
The Hazel Jule Cobalt Silver Mining Company, Limited	Toronto	February 20	500,000
The Highland Mary Gold Mines, Limited	Toronto	September 16	3,000,000
The Hillman Copper Company, Limited	Sault Ste. Marie	March 6	60,000
The Independence Larder Lake Gold Mines, Limited	Toronto	October 4	4,000,000
The Ivanhoe Cobalt Silver Mining Company, Limited	Ottawa	December 27	1,000,000
The Jack Pot Cobalt Silver Mining Company, Limited	Toronto	January 16	750,000
The James Township Silver Mines, Limited	Toronto	May 10	1,500,000
The Jessop Prospecting and Mining Company, Limited	Toronto	February 20	1,000,000
The Kelly Island Lime Company, Limited	Windsor	February 22	40,000
The Knickerbocker Cobalt Mines, Limited	Toronto	January 16	550,000
The Lake Temiskaming Silver Mining Company, Limited	Ottawa	January 16	850,000
The Lansing Cobalt Mining Company, Limited	Windsor	May 31	400,000
The Larder Gold Queen, Limited	New Liskeard	April 12	1,500,000
The Larder Lake Gold Hill Mines, Limited	Toronto	April 23	1,000,000
The Larder Lake International Mines, Limited	Ottawa	July 19	5,000,000
The Larder Lake Proprietary Gold Fields, Limited	Toronto	January 16	3,000,000
The Lasalle Development Company, Limited	Toronto	March 18	1,000,000
The Lawson Mine, Limited	Toronto	April 23	5,000,000
The Lincoln Nipissing Development Company, Limited	St. Catharines	February 6	160,000
The Lincoln Silver Mining Company, Limited	Cobalt	December 23	300,000
The Load Star Mining Company, Limited	Toronto	June 28	3,000,000
The Lombard Cobalt Silver Mines, Limited	Toronto	March 27	1,000,000
The Lucky Strike Cobalt Silver Mining Company, Limited	Cobalt	March 13	3,000,000
The MacRae Mining Company, Limited	Ottawa	January 30	1,000,000
The Massive Corundum Company of Ontario, Limited	Niagara Falls	February 13	2,000,000
The Master-Stein Cobalt Mining Company, Limited	Winnipeg	May 22	1,000,000
The McConnell Silver Mining Company of Cobalt, Limited	Ottawa	February 6	200,000
The McGill Cobalt Mining Company, Limited	Cornwall	May 31	1,000,000
The McKinnon Mines, Limited	Haileybury	May 17	1,000,000
The Meridian Bay Mining Company, Limited	Berlin	January 16	1,000,000
The Nanton Coal Fields, Limited	Ottawa	August 21	100,000
The Niagara Cobalt Silver Mining Company, Limited	Niagara Falls	January 16	750,000
The Niagara Falls Mining and Drilling Company, Limited	Niagara Falls	April 3	16,000
The Night Hawk Lake Mining Company, Limited	Toronto	October 17	70,000
The Nipissing Gold Estates, Limited	Cobalt	May 31	4,000,000
The Nonsuch Cobalt Silver Company, Limited	Toronto	May 1	50,000
The North American Oil and Gas Company, Limited	Niagara Falls	October 11	1,000,000
The North Bay Cobalt Silver Mining Company, Limited	North Bay	February 25	300,000
The North Canadian Gold Mines, Limited	Toronto	June 28	1,000,000
The North Cobalt Mines, Limited	Cobalt	November 1	1,000,000
The North Star Oil and Gas Company, Limited	Chatham	November 8	36,000
The Ottawa Mica Mining Company, Limited	Ottawa	April 23	350,000
The Ottawa Prospecting & Development Company Limited	Haileybury	June 12	200,000
The Oxford Prospecting and Mining Company, Limited	Cobalt	August 29	20,000
The Peel Oil and Gas Company, Limited	Toronto	August 29	100,000
The Pense Cobalt Mining Company, Limited	Toronto	February 18	1,000,000
The Perfect Brick and Tile Company, Limited	Ottawa	March 6	100,000
The Prince Rupert Cobalt Silver Mines, Limited	Cobalt	January 18	1,000,000
The Producers' Natural Gas Company, Limited	Hamilton	September 12	100,000
The Red Jack Mining Company, Limited	Midland	June 6	500,000
The Rex Argent Mines Company, Limited	Latchford	October 17	100,000
The Ridgeway Mining Company, Limited	Toronto	October 25	500,000
The Robinet Brick Company, Limited	Sandwich	February 6	40,000
The Rush Larder Lake Mining Company, Limited	Toronto	April 3	1,000,000
The Safe Oil and Gas Company, Limited	Chatham	February 28	150,000
The St. Lawrence Lumber & Mining Company, Limited	Cornwall	December 18	50,000
The Silbert Consolidated Mining Company, Limited	Toronto	March 1	2,000,000
The Silverfield Cobalt Mining Company, Limited	Toronto	January 4	200,000
The Silver Bird Cobalt Mines, Limited	Toronto	January 31	1,500,000
The Silver Heels Mining Company, Limited	Toronto	January 16	500,000
The Silver Ridge Mining Company, Limited	Toronto	January 23	1,000,000
The Silver Rock Mining Company, Limited	Cobalt	January 26	1,000,000
The Soo Larder Lake Exploration Company, Limited	Sault Ste. Marie	April 17	150,000

Mining Companies Incorporated 1907—Continued

Name of Company.	Head Office	Date of Incorporation.	Capital. $
The South-Western Oil and Gas Lands, Limited	Petrolea	February 20	60,000
The Stadacona Cobalt Silver Mining Company, Limited	Cobalt	February 18	1,000,000
The Strathcona Silver Mining Company of Cobalt, Limited	Toronto	March 1	800,000
The Temagami Copper Company, Limited	Toronto	April 19	2,000,000
The Tiffany Cobalt Mines, Limited	Cobalt	January 23	600,000
The Tilbury Town Gas Company, Limited	Chatham	May 31	40,000
The Toronto Tilbury Oil and Gas Company, Limited	Toronto	July 10	750,000
The Towinenie Old Indian Mining Company, Limited	Toronto	July 10	2,500,000
The Treasure Island Gold Mining Company, Limited	Toronto	October 4	1,000,000
The Veterans Prospecting and Mining Company, Limited	Toronto	January 31	1,000,000
The Viceroy Cobalt Mining Company, Limited	Toronto	February 6	300,000
The Victoria Creek Mining & Development Company, Ltd.	Ottawa	June 6	40,000
The Webbwood Copper Mines, Limited	Toronto	June 26	1,000,000
The Welland Copper Company, Limited	Toronto	April 23	1,000,000
The Wendigo Crater Mines, Limited	Cobalt	January 31	40,000
The Wentworth Quarry Company, Limited	Hamilton	December 28, 1906.	60,000
The Westmont Silver Mining Company, Limited	Toronto	November 22	60,000
The Wettlaufer Cobalt Mining Company, Limited	Toronto	August 14	1,000,000
The Winnipeg-Cobalt Prospecting & Development Co., Ltd.	Kenora	March 15	500,000
Tighe Larder Lake Gold Mines, Limited	Toronto	November 8	4,000,000
Tilbury-Romney Gas and Oil Fields, Limited	Toronto	May 24	300,000
Wayne Cobalt Silver Mining Company, Limited	Windsor	February 1	50,000
Wee-Tu Mining Company, Limited	Latchford	July 8	300,000
Wilbur Iron Ore Company, Limited	Toronto	September 3	500,000
Wilgar Lake Cobalt Mining Company, Limited	Toronto	January 26	100,000
W. J. Trethewey Company, Limited	Toronto	March 15	1,000,000

Mining Companies Licensed in 1907

Name of Company.	Provincial Head Office.	Date of License.	Capital. $
Bonanza Cobalt Mines Company, Limited	Toronto	March 22	1,000,000
Bully Boy Mining Company of Ontario, Limited	Kenora	October 11	250,000
Cobalt Coalition Mining Company	Cobalt	June 28	250,000
Cobalt Wonder Mining Company	Toronto	March 22	1,000,000
Continental Cobalt Mines Company, Limited	Haileybury	June 12	1,000,000
Net Lake Mines, Limited	Toronto	June 12	....
Oeto Oil Company	Sarnia	May 10	40,000
Pequot Smelting Company	Cobalt	January 11	10,000
The Abitibi Mining Company, Limited	Toronto	February 8	....
The Anglo-Canadian Petroleum Company, Limited	Petrolea	May 3	250,000
The Kennedy Oil and Gas Company	Chatham	December 12, 1906.	15,000
The Nichols Chemical Company of Canada	Tweed	April 19	....
The Philadelphia Cobalt Mining Company	Toronto	April 19	2,000,000
The Vancouver Portland Cement Company, Limited	Toronto	December 27	....
Yukon District Gold Mining Company, Limited	Toronto	November 7	....

N.B. Where no amount of capital is stated, the companies are of Dominion incorporation and no amount of capital is mentioned in the license.

Mining Accidents

There were 22 men killed in mining accidents in 1907. Of these 4 were killed above ground and 18 below ground. The cause of the fatal accidents below ground were as follows: Reloading missed hole, 2; drilled into missed hole, 2; picked into explosive in the muck or in the bottom of old drill hole, 5; falling from bucket, 4; fall of ore car down shaft, 1; fall of rock, 3; falling down shaft, 1.

From this it will be seen that 9 of the 18 men fatally injured below ground met their death through the premature explosion of some explosive. The 22 fatal accidents occurred in 16 mines.

Helen Mine

There were eight minor accidents at the Helen mine during 1907. All of these accidents were slight, and are given in detail in the table of accidents.

Canadian Copper Company

At the Canadian Copper Company's works and mines six accidents happened during the year, resulting in the death of three men; all three fatal accidents occurring on the surface.

At the Creighton mine, January 15th, John McDonald, shift boss, had his foot caught between the draw bars of two cars on the siding, necessitating the amputation of his foot.

At the Crean Hill mine, May 5th, Harry Sollers, rock house foreman, fell from the crusher floor to the ground, a distance of about forty feet, and was killed. The deceased had stopped the crusher for repairs to the screen, and when these were finished, instead of going up to the crusher floor by means of the stairs, he climbed up the side of the opening which is protected by railing on the crusher floor. He reached the opening, gave instructions to go ahead, and started to descend, when he lost his hold and fell to the ground.

At the Creighton mine, on May 23rd, Yurko Olijnyk, a Polish boy, who was employed as rock picker in the ore house, was killed by having his clothes caught in the shafting and being wound around it. Before the accident, the boy, who was 17 years old, was sent to loosen the ore in the chute, where it feeds on to the screen, by means of a bar. The boy was standing a few feet behind the shafting, and in some way which could not be explained, his coat was caught in the shafting, and he was carried over by it. There was no witness to the accident, and consequently full particulars could not be ascertained.

On September 18th, at Crean Hill mine, Frank Prestofrange, an ore sorter, was killed by being caught between the ore-sorting travelling belt and the roller. During the day's work a certain amount of ore falls from the belt to the floor, and is cleaned up by the boys at the end of each shift. On the day of the accident, the motor which drives the belt was stopped at about 5.30 p.m., and while the belt was moving slowly, the boy began to clean up the ore under the belt, and in doing so was caught and drawn between the roller and the belt.

The coroner's jury brought in the following verdict: "That the death of Frank Prestofrange on the 18th day of September, 1907, was due to his own carelessness, in going under the ore belt while it was in motion."

On November 16th, at Crean Hill mine, Matti Hyppa, mucker, was seriously injured by striking a piece of gelignite in the muck, with his pick. He was seriously injured in the side, and lost the sight of both eyes.

On November 28th, at the Creighton mine, Romeo Favero, aged 21 years, an Italian, was struck by a piece of loose rock, injuring his leg so seriously that amputation of the foot was necessary. Favero was sledging a large piece of rock at the foot of a stope when a lump of loose rock above him, weighing about 200 pounds, rolled down the stope, striking his leg just above the ankle.

Mond Nickel Company

On October 24th, at Victoria mine, William Patterson, machine helper, was instantly killed by a piece of rock falling on him in the third level of the mine. The stope had been scaled a short time before the accident, and was thought to be perfectly safe.

The coroner's jury brought in this verdict: "William Patterson came to his death through being accidentally struck on the head by a piece of falling ground."

Canada Corundum Company

On February 25th at the Craig mine, Craigmont, Fred. Gibson, a drill helper, was killed by being crushed under a large piece of falling rock.

On the morning of the accident, the powderman and the foreman of the mine worked for some time at the piece of rock, which afterwards fell, trying to take it down, before allowing anyone to work under it. They were unable to do so, and Gibson, the deceased, had just commenced work on the floor of the cut, under this rock, when it fell, killing him instantly.

The coroner's jury returned the following verdict: "That Fred. Gibson came to his death by being crushed by a falling rock, that it was accidental, and due care, as is taken in such cases, was exercised by Messrs. Campbell and Lents, (powderman and foreman), in this one; that it occurred on Monday, February 25th, 1907, in the township of Raglan."

Hungerford Pyrites Mine

At the Hungerford mine, July 22nd, James Chambers, engineer, was killed by being caught in the fly wheel of the compressor. Chambers shut down his compressor to tighten up a loose eccentric bolt, and neglected to open up the drip of the steam chest. He put his head and shoulders through the fly wheel of the compressor to tighten the loose bolt, and the weight of his body caused the fly wheel to revolve enough to move the slide valve a little, thus admitting the unreleased steam in the valve chest to the cylinder, and causing the compressor to make a quarter revolution and pinning the engineer between a spoke of the wheel and the connecting rod.

Hanlan Mica Mine

At the Hanlan mica mine on Monday afternoon, September 9th, John Waffle, pit-boss, was killed through falling off a bucket while riding to the surface. On the afternoon of the day of the accident Waffle, who was in the bottom of the pit, which is 120 feet deep, stepped into a loaded bucket, which was leaving the bottom, and rode to within about 8 feet of the surface. For some unknown reason he released his hold on the cable, and falling to the bottom of the pit, was instantly killed.

Nova Scotia Silver Mine

At the Nova Scotia mine, about 9.20 a.m. on January 7th, John Camtfield, machine drill-runner, and Sutherland Stewart, machine drill-helper, were killed through a premature discharge of dynamite. The two men charged three holes in the bottom of the shaft, lighted them and came to the surface. Of these three holes only one hole exploded, the other two for some unknown reason missing fire. After waiting about 20 minutes on the surface, the two men, having in the meantime prepared two more exploders, got two sticks of dynamite, and went to the bottom of the shaft. No communication took place between the men and the surface men after going into the shaft the second time. The bucket was lowered to the bottom for the purpose of hoisting water, which one of the men, presumably the helper, was engaged in filling at the time of the explosion, which occurred about 30 minutes after the time the men went below. The top men immediately raised the alarm, and four went down into the shaft and found both men dead. After taking out the bodies it was found on further examination of the shaft, that one of the missed holes had been cleaned out and the old exploder removed. The gun which was used for cleaning out the holes was found very badly broken, as if it had been in the hole at the time of the explosion. It appeared, therefore, that the machine man had been cleaning out the second missed hole with the gun and had got too near the old exploder, and thus caused the accident.

The coroner's jury brought in a verdict that the said John Camtfield and Sutherland Stewart came to their death by the explosion of dynamite in the shaft of the mine, the cause of said explosion being unknown, and that in their opinion no blame was attached to the company or officers of the mine, but that the occurrence was accidental

Kerr Lake Silver Mine

At the Kerr Lake mine on January 24th, at 5 p.m., Michael McNulty, timberman, was killed by a large rock falling on him from the stope of the 65-foot level. Deceased at the time of the accident was engaged in putting in timbers for the chute. Some blasting had been done to widen the stope to make room for the timbers. After blasting, the men had been set to work to scale down all the loose rock, and reported having done so. The rock which fell on deceased came from the stope of the hanging wall about 6 feet above the top of the drift, rolled on to the bottom of the chute against the hanging wall and rebounded, pinning the deceased against the opposite wall.

Trethewey Silver Mine

At the Trethewey mine on March 8th, George Thompson, shift boss, was killed through a premature discharge of dynamite in the heading of a drift in which all the holes had been reported exploded. On March 7th, 14 machine holes were blasted in the heading of the drift in which the accident occurred. The muckers were engaged mucking out the heading. When it was nearly cleaned out, Thompson went to the heading and began to scale it. Very shortly after, an explosion was heard, and the men on going into the drift found the deceased lying on the track about 12 feet from the heading. It would appear from the small quantity of freshly broken rock found at the time of the accident, that the accident was caused by there being a little explosive left in the bottom of one of the holes, unexploded, or that some of the explosive had been left by one of the holes cutting off another, and that the deceased had picked into this, causing the explosion.

O'Brien Silver Mine

On June 3rd, at the O'Brien mine, David Blair and Harry Weldy were killed by drilling into the bottom of a missed hole at the 100-foot level of No. 1 shaft. The coroner's jury brought in a verdict that they came to their death by injuries caused by the accidental discharge of powder in a missed hole.

Temiskaming and Hudson Bay Silver Mine

At the Temiskaming and Hudson Bay mine on 3rd August, 1907, Isaac McIsaac was killed by falling off the bucket. Deceased, who was engaged in timbering, had with his helper ridden to the surface on the bucket. The helper had stepped out, and deceased while still in the bucket, was getting out some measuring sticks, when the catch slipped off the foot brake of the hoist, and the bucket dropped about 10 or 15 feet in the shaft. The hoistman then stopped the bucket by means of the foot brake, and the deceased was thrown out of the bucket to the bottom of the shaft.

Right-of-way Silver Mine

At the Right-of-Way mine on 17th September, 1907, at 9.30 a.m., Ovile Lessard, miner, was killed by falling out of the bucket down No. 2 shaft. At the time of the accident the shaft was 50 feet deep and Lessard was working at the bottom. In leaving the bottom of the shaft Lessard was sitting down in the bucket, and when the latter reached the surface it was empty and upside down. It appeared, therefore, that in some unexplainable way the link on the side of the bucket for holdng it upright had slipped off, causing the bucket to overturn.

Green-Meehan Mine

At the Green-Meehan mine, September 9th, Fred. Patipaw, machine drill runner, received injuries which resulted in his death September 11th. No. 1 shaft is 100 feet deep. The first round of holes was fired on the night of the 7th, for cutting the station on the 100-foot level. No work was done on Sunday. On Monday morning two

machine men, Albert Morrissey and Fred. Patipaw, the deceased, went down in the bucket, leaving their helpers to attend to work on the surface. The air was blowing into the bottom of the shaft at 7 a.m., but Patipaw turned off the air before going down the shaft. After a few minutes the engineer got the signal to hoist, and Patipaw came to the surface with two or three unfired fuse in his hand. He went to the house where the fuse was kept and remarked that he felt dizzy. When he got back to the shaft Morrissey was still at the bottom and yelled for the bucket. Patipaw got on and was lowered to the bottom. He had not been down for more than half a minute when the engineer started to hoist the bucket, and when the bucket reached a point ten or fifteen feet from the bottom, the two men at the top saw the lights go out and the bucket sway. The foreman and another man went down and found both Morrissey and Patipaw lying in the bottom. Both men were brought to the top, and it was found that Morrissey was overcome with gas, but that Patipaw had landed on his head, sustaining a compound fracture of the left side of the skull. It was probably due to the effects of the gas that he fell from the bucket.

McKinley=Darragh=Savage Silver Mines

At the McKinley-Darragh mine, No. 2 shaft, on October 18th at 7.40 a.m., John Cobush, trammer, was killed, being struck on the head by a car falling from the 75-foot level to the 125-foot level of the mine. Cobush's partner went to send the bucket from the 75-foot level to the 125-foot level and allowed the truck on which the bucket sits to run into the shaft. Cobush was waiting at the 125-foot level to take off the bucket when his partner should lower it, and was struck by the falling truck. The shaft opening at the 75-foot level was protected by a door which is lowered when tramming is going on at that level, but the door was opened to allow the bucket to be lowered to the 125-foot level

Cobalt Lake Silver Mine

At the Cobalt Lake No. 1 shaft, at 9.30 p.m., on 28th November, Allen Allore, drill runner, and Philip Roy, helper, were killed by a premature explosion caused presumably by Allore picking into a missed or cut-off hole. The day shift had fired the holes in the bottom of the shaft by battery between 11 and 12 o'clock in the morning, and mucking had been going on all the afternoon and until the time of the accident at night. Shortly before the accident, the bucket tender saw Allore pick up a stick of dynamite and place it to one side, and about five minutes afterwards the explosion occurred. From an examination of the shaft after the accident, the fatality was evidently caused by Allore striking a missed or cut off hole with his pick. The stick of dynamite which was laid to one side had the electric exploder, which had evidently been taken from the hole by Allore.

At Cobalt Lake shaft No. 4, at 6 p.m., December 17th, Joseph Tesniere, mucker, fell down the shaft from the 86-foot level to the bottom and was killed. Tesniere had been employed during the day on the 86-foot level and about 5 o'clock he went up the raise to take candles to the men, and until 6 o'clock assisted them sacking ore. At 6 o'clock Tesniere with two men who were in the raise came down to the mouth of the No. 4 cross-cut. Tesniere here handed one of the men, Richer, the latter's candle-stick, saying that his mitts were in the vein where he was working during the day and that he was going to get them. The two men who were with Tesniere then went to the surface, and Tesniere was not seen again until the night shift found him lying in the bottom of the shaft between 7 and 8 o'clock. The deceased had apparently when coming out of the cross-cut, to go to the ladderway, walked or fallen into the shaft. The coroner's jury brought in a verdict that Tesniere was found dead in shaft No. 4 of the Cobalt Lake mine, but that the cause of death did not appear.

Nipissing Silver Mine

At the Nipissing mine, No. 12 shaft, on December 9th, Andrn Dudeck was killed by an accidental explosion of gelignite. Deceased, who was a foreigner, was employed along with a partner, mucking in the drift at No. 12 shaft. A few minutes before the accident occurred the deceased's partner left the drift for some tools; during his absence deceased must have been picking down rock and in doing so struck a stick of gelignite, which apparently had got in the muck from a cut-off hole in the heading.

Cobalt Townsite Silver Mine

At the Cobalt Townsite mine, December 18th, B. W. Leyson, superintendent, and J. McKnight, mucker, were injured, McKnight dying from his injuries shortly afterwards. McKnight was taking down ore and stuck his pick into a cut-off hole containing gelignite, causing it to explode. He was seriously injured about the face and arms. Mr. Leyson was standing directly behind him inspecting the work and had his right arm broken.

Beaver Silver Mine

At the Beaver mine, December 30th, W. Johns and J. West were injured by picking into a small piece of gelignite that was apparently left in the bottom of one of the cut-off holes in the shaft. Both men recovered in a short time.

The following table summarizes the accidents which occurred in the mines of the Province during 1907. It shows that in a total of 35 casualties, 22 men were killed, and 9 slightly and 10 seriously injured. The number killed was exactly double the number in 1906, and there can be no doubt that the rate of mortality from accident in our mines is excessive. Analyzing the table, it will be seen that of the fatal accidents, 16 were in mines of the Cobalt camp, 4 in those of the Sudbury nickel field, and 2 elsewhere. Now, the number of men employed at Cobalt is returned as 2,038, and in the nickel mines as 1,824. It is, therefore, evident that the death rate in the former mines is much greater than in the latter—in fact, nearly 3.5 times as great.

It is difficult to account satisfactorily for so great a difference. The class of labor employed in the Sudbury mines, consisting as it does, largely of men of foreign origin, cannot be regarded as superior to that at Cobalt, where the fame of the mines has drawn skilled miners from all parts of the world. Doubtless at the first opening of the Cobalt mines many men inexperienced in mining found employment, but these were drawn largely from the lumbering and farming classes of the community, wanting neither in intelligence nor dexterity.

Something is probably attributable to the character of the workings: for the most part those at Cobalt are small, requiring few men at each and consequently not favorable to so thorough an organization, especially in the matter of handling explosives, as the larger mines of the Sudbury field, where the ore is of lower grade, but occurs in much larger quantity.

It is not apparent what further aid can be rendered by legislation: the regulations embodied in the Mining Act, if carried out with strictness, probably being sufficient to eliminate nearly all causes of accident which can be foreseen or guarded against. A heavy responsibility rests upon managers, superintendents and foremen not only to insist upon the utmost possible care being taken by those under them, but also themselves to set an example of prudence and determination to avoid all risks or dangerous practices. Example is better than precept, and the remarks of Mr. E. T. Corkill, Inspector of Mines, who discusses the same matter in his report on the Mines of Ontario, are commended to the thoughtful attention of all concerned with the management of mines. From a purely selfish point of view, a low death rate is a most desirable thing for a mine owner; but human life is precious, and apart from interested motives, nothing should be left undone to rob the business of mining of as much of its hazard as possible.

Table of Mining Accidents, 1907

No.	Date.	Mine or Works.	Name of Injured Person.	Result of injury. Slight.	Result of injury. Serious.	Result of injury. Fatal.	Above ground.	Below ground.	Nature of Injury.	Cause of Accident.
1	Jan. 7	Nova Scotia	John Camtfield			1		1	Killed instantly	Reloading missed hole.
			Sutherland Stuart			1		1	" "	
2	" 15	Canadian Copper Co	John McDonald		1		1		Foot crushed	Caught between two cars
3	" 24	Kerr Lake mine	Michael McNulty			1		1	Killed instantly	Fall of rock.
4	Feb. 14	Helen mine	George Dizzozi	1			1		Shoulder and back bruised	Fall from car on ice.
5	" 24	Canada Corundum Co.	Fred Gibson			1		1	Killed instantly	Fall of rock.
6	Mar. 8	Trethewey mine	George Thompson			1		1	Killed instantly	Picking into explosive in bottom of hole
7	May 4	Canadian Copper Co. (Crean Hill mine)	Harry Sollers			1	1		Died in twelve hours	Fell from crusher floor to ground.
8	May 21	Helen mine	John Curtis	1				1	Side bruised	Fall off ladder.
9	" 23	Canadian Copper Co. (Creighton mine)	Yurko Olijnyk			1	1		Died same evening	Clothing caught in shafting in rock house.
10	" 29	Helen mine	George Sundblad	1				1	Leg bruised	Fell into ore chute.
11	" 30	Big Ben Cobalt mine	J. Larmont		1			1	Badly bruised	Fell into shaft.
12	June 3	O'Brien mine	Daniel Blair			1		1	Killed instantly	Drilled into missed hole.
			Harry Weldy			1		1	Died following day	
13	" 24	Helen mine	Andruck Michael	1				1	Scalp wound	Ore falling down chute.
14	July 22	Hungerford mine	James Chambers			1	1		Fracture of lower jaw and base of skull.	Caught between fly wheel and connecting rod of compressor.
15	Aug. 3	Temiskaming & Hudson Bay mine	Isaac McIsaac			1		1	Killed instantly	Fell from bucket.
16	Sept. 9	Hanlan mine	John Waffle			1		1	" "	" " "
17	" 9	Green-Meehan mine	Fred Patipaw			1		1	Fracture of skull	Overcome by gas and fell from bucket.
18	" 17	Right-of-Way mine	Ovile Lessard			1		1	Killed instantly	Fell from bucket.
19	" 18	Canadian Copper Co. (Crean Hill mine)	Frank Prestofrange			1	1		Killed instantly	Crushed between belt and roller of picking table.
20	" 19	Cobalt Central	James O'Donnell		1			1	Eyes injured	Explosion of powder in muck.
21	Oct. 18	McKinley-Darragh mine	John Colush			1		1	" "	Fall of car down shaft.
22	" 24	Victoria mine	William Patterson			1		1	" "	Fall of ore.
23	Nov. 4	Helen mine	Edward Shepard	1				1	Scalp wound	Ore falling down stope.
24	" 4	O'Brien mine	Oratic Tirobossi		1		1		Eye injured	Picking into explosive.
25	" 8	Foster mine	Alexander Mackenzie		1			1	Injury to right eye	Drilled into unexploded dynamite.
			Simon Guthro		1			1	Right arm broken	
26	" 16	Canadian Copper Co. (Crean Hill mine)	Matti Hyppa		1			1	Eyes injured	Picking into gelignite.
27	" 28	Cobalt Lake mine	Allen Allore			1		1	Killed instantly	Picking into missed hole.
			Philip Roy			1		1	" "	
28	" 28	Canadian Copper Co. (Creighton mine)	Romeo Favaro		1			1	Foot crushed	Rock rolling down stope.
29	Dec. 9	Nipissing mine	Andrn Dudeck			1		1	Killed instantly	Picking into piece of gelignite in muck.
30	" 17	Cobalt Lake mine	Joseph Tesniere			1		1	" "	Fell down shaft.
31	" 17	Helen mine	Franz Manilla	1				1	Face injured by fine rock	Caught by blast, returning before it exploded,
32	" 18	Cobalt Townsite mine	James McKnight			1		1	Injuries resulting in death	Struck piece of gelignite in muck.
			B. W. Leyson		1			1	Right arm fractured	
33	" 20	Helen mine	Alex Brown	1			1		Bruise	Caught between two dump cars.
34	" 26	Helen mine	Walter Falk	1				1	Scalp wound	Rock falling from roof.
35	" 30	Beaver mine	W. Johns		1			1	Face cut	Struck piece of gelignite in muck.
			J. West	1				1	" "	
		Total casualties		9	10	22	8	33		

The Mining Divisions

The administration of the mining lands of the Crown is now by virtue of the mining law very largely in the hands of the Recorders of Mining Divisions, of which twelve have been set apart under the Mines Act. In three of these Divisions, however, there is not sufficient business to warrant the appointment of local Recorders, and applications for the recording of mining claims are made to and passed upon by the Deputy Minister of Mines, Toronto, as well as for claims situated in the southeastern portion of the Province in which no Mining Divisions have yet been created.

Reports have been obtained from the Recorders of the several Mining Divisions, briefly summing up the transactions of the year, and they are herewith reproduced.

Temiskaming

Mr. George T. Smith, Mining Recorder of Temiskaming Mining Division, whose office is at Haileybury, makes the following report:

Below please find statement of business transacted in this Mining Division during year ending 31st December, 1907.

Miners' licenses issued	4,676
Renewal licenses issued	2 017
Mining claims recorded	7,860
Received for licenses and fees	$130,890.30

The past year was a very active one in this Mining Division. In the early part of the year the rush to Larder Lake was an unprecedented one in the history of this country, many discoveries of gold being reported. Later on the activity extended to the Montreal River district, and still later on the country lying south of the township of Lorrain claimed considerable attention from a large number of prospectors.

The opening of a recording office at Larder Lake relieved the office at Haileybury to a considerable extent. Quite a number of discoveries of gold were reported from the Abitibi Lake region.

Many valuable discoveries were made in the townships of James, Smythe and Tudhope, on the Montreal river, and considerable development work has been done in all these townships.

The contry south of Lorrain has been showing up well. A large number of claims have been recorded. Many good discoveries, chiefly of cobalt and silver, have been made, and a number of properties have changed hands. Though the season was somewhat advanced before much attention was paid to this section, a good deal of development work has been going on It is claimed that on the opening of navigation considerable shipments of ore will be made and a busy season is anticipated.

Coleman

Mr. T. A. McArthur, Assistant Recorder of Coleman Special Mining Division, reports as follows:

Herewith is statement in connection with Coleman Special Mining Division for 1907.

Miners' licenses issued	2,071
Miners' licenses renewed	861
Number of applications for mining claims recorded	291

Total amount of fees collected and remitted to the Department $32,599.25, a small portion of which has been refunded in cases of rejected applications.

In 1905 this township had seventeen shipping mines.

In 1906 the number increased to nineteen, and in 1907 the township of Coleman had twenty-nine shippers.

Sudbury

The Mining Recorder for the Sudbury Mining Division is Mr. F. F. Lemieux, who reports:

The business of this office shows a marked increase for 1907, the number of licenses issued being 718, number of renewals of licenses 104, and the number of claims recorded 456.

The amount of money received and remitted to the Department was $11,774.00.

Prospecting has been general over the whole district, notably in the Temagami Forest Reserve, and in the unsurveyed territory east of the township of Garrow, where discoveries of silver, copper and gold have been made. Many claims have been taken up for iron in the townships of Norman and Rathbun. Along the "Soo" branch of the Canadian Pacific railway, in the townships of Spragge, Salter and Berth 123, claims for copper have been taken up. To the north and west of Sudbury iron discoveries have been made, which according to the discoverers, are of great value.

The land rolls and maps of the different townships of this Division have been much used by prospectors and others, and are of great practical value, judging from the expressions of those using them for researches.

Sault St. Marie

Mr. S. T. Bowker, Recorder of the Sault Ste. Marie Mining Division, makes the following report:

Pursuant to your instructions of the 7th inst., I beg to report as follows on the operations of my office during the year 1907:

The total number of miners' licenses issued from this office was 376.

The total number of mining claims recorded was 291.

The total amount of fees forwarded to the Department was $7,048.11.

Port Arthur

Mr. J. W. Morgan, the Recorder at Port Arthur, says:

In compliance with your request, I beg to make the following brief report concerning the transactions of this office: During the year 1907, 259 miners' licenses were issued, 317 claims recorded, $5,103.40 was collected for licenses and recording claims. All of this money has been remitted to the Department. Six hundred and fifty-four lithograph maps, blue prints and tracings were furnished to prospectors, 402 copies of the Mines Act and reports distributed, and 1,075 letters and post cards containing information or instruction were written and mailed.

I have also to report that much new territory has been explored in this Mining Division, and discoveries of iron, gold and silver made where these minerals were not previously known to exist. Large deposits of high grade bog iron ore have been found near the boundary between Thunder Bay and Rainy River districts, a number of gold claims have been taken up near Sturgeon lake, red hematite has been located near Beck siding in the township of McGregor, as well as in the township of Conmee, along the Mattawin river and east of lake Nepigon. Extensive deposits of both magnetite and red hematite are reported as having been found near Savant lake in the northwest part of this Mining Division.

Lieut.-Col. S. W. Ray, of Port Arthur, has opened up the Tip-top copper mine, and has purchased a smelting plant, which could not be taken in owing to the want of a road. Lieut.-Col. George A. Shaw, of Toronto, is developing a magnetic iron ore property near Silver Mountain, also a silver location west of Silver mountain. The following parties have been doing considerable work: Alexander L. Durupt on iron claims near Beck siding; R. P. Kelly and Dr. Ewing of Fort William on iron ore locations in the Mattawin district, where F. Hillé also is developing an iron ore property.

Many new prospectors from British Columbia and the United States have written me expressing their intention to begin explorations in the country north of lake Superior early next spring.

Kenora

Mr. C. W. Belyea, Mining Recorder for the Kenora Division, reports as follows:

Re yours of January 7th, asking for brief report of transactions in this Mining Division for the year 1907, I have to report the following:

Number of miners' licenses issued	88
Received for licenses and fees	$1,458.50

The mines of the Lake of the Woods district have suffered from the general financial depression of the last year. Only two mines, the Grace mine and the Empire mine, have been working during this time. Both have stamp mills and have been producing gold, and are in active operation to-day. The principal mines, the Sultana, Mikado and Regina, have been closed down for some time. However, I understand that the

Regina mine is being pumped out, and that the trustee, Gen. Sir Henry Wilkinson, K.C.B., has arrived from England, and no doubt the mine will be further developed this year.

The Mikado mine has been offered for sale, and a party is now in the east forming a company to purchase same. It is believed that this mine still holds large quantities of pay ore.

There would seem to be every reason to expect a resumption of work on many of the old mines in the near future. There is no doubt that the district has been suffering for the last three or four years from the result of the wild cat speculation in stock (not mines) of the boom days. Moneyed men are beginning to look this way again, and a number of recent discoveries are likely to attract much attention.

Some very interesting finds have been made on the line of the Grand Trunk Pacific. Samples of stibnite and galena carrying silver have been brought in by the workmen at various times.

The Northern pyrites mine, some miles north of Dinorwic, has been opened up, and the owners are well pleased with their prospects.

The mines of the Sturgeon lake district north of Ignace will receive a great impetus on completion of the Superior section of the Grand Trunk Pacific railway, as at present it costs $45.00 per ton for freighting supplies. This has compelled many to suspend operations.

A vein 150 feet wide carrying copper and gold in paying quantities has been found quite recently by David Guthrie and G. S. Campbell, two prospectors, north of Pine station on the Canadian Pacific railway. Samples of fine muscovite have been brought in from this new section. Much iron ore has also been found, but this has not been worked to any extent.

Parry Sound

The Recorder for the Parry Sound Mining Division, Mr. H. F. McQuire, reports:—

There have been one hundred and two claims taken up in the district to December 31st, 1907—27 of them being in the township of Lount. There is considerable activity in this township. The samples produced are of iron, some also show copper and traces of nickel. Several of the properties are under option and will be more thoroughly prospected during the season of 1908.

In the immediate vicinity of Parry Sound a few claims have been taken up for feldspar. With the exception of the Parry Sound Copper Mining Company, the owners of all copper prospects in the district have done little or no development. The former company, whose property is known as the McGown mine, have at present a small force drifting from one of their old shafts, with the expectation of striking the rich bornite vein from which several car loads were taken some years ago.

Indications point to some activity in iron and mica during 1908, as a number of claims have been applied for north of Parry Sound which will be prospected next season.

The convenience of the office to the district seems to be appreciated, and it will be brought into closer touch with northern and westerly points on the opening for traffic of the Canadian Northern Ontario railway, and the Canadian Pacific line to Sudbury during the summer of 1908.

Larder Lake

The Recorder's Office for the Larder Lake Mining Division is at Larder city, Mr. J. A. Hough being Recorder. Mr. Hough reports:—

A total of 3,813 mining claims were recorded during the year 1907 in the Larder Lake Mining Division, and a total of 22,780 days' work were recorded as having been performed on these claims during the same period.

The work was filed as follows: 30 days' work on 614 claims; 60 days on 25 claims; 90 days on 13 claims. This leaves a balance of 3,148 claims staked during the year on which no work was reported. In addition, 13,990 days' work was recorded as having been performed on mining claims staked in the Division prior to 1907, making a total of 36,770 days' work reported for the year.

1,497 mining claims were transferred, and the books show 481 of these as being held by 47 chartered companies.

37 certificates of record were granted and 8 certificates of performance of working conditions (in full). One mining claim was patented.

It should be remembered that the recording office at Larder Lake was opened in June, 1907, and that prior to that time the recording for the Division was done at Haileybury.

The vast majority of the claims were recorded at Haileybury during the first four months of the year.

The particularly wet season, the bad plague of flies and the poor transportation facilities were accountable for the non-performance of development work on a large number of claims.

Some parts of the Division show so much staking, restaking, overlapping, and other irregularities, that it was found to be impossible to identify or straighten out some of the claims, and they have consequently been left idle. Disputes could not be filed owing to the number of posts on the ground and the illegibility of the writing on the posts.

The building of roads by the Government from Boston and from Tomstown, the expiration of all extensions of time, the promised and expected shipment of gold bricks from the stamp-mills now in course of erection here, should lead to a very busy season for 1908.

Montreal River

Mr. T. H. Torrance, the Recorder for the Montreal River Mining Division, whose office is at Latchford, writes thus:—

I beg to make a brief report of the business transacted in this office from the date of its opening, June 1st, 1907, to December 31st, 1907:—

Number of licenses issued	273
Number of applications for mining claims received and recorded	866
Number of applications for Working Permits received and granted	107
Moneys collected and remitted to Department	$16,168 40

There has been a great deal of prospecting in this Division during the past season, and while mining is at present only in its prospecting stage, a number of very rich finds of native silver and cobalt have been made, particularly in the townshp of James, and in the vicinity of Silver and Hubert lakes, also around Anvil lake, where are situated the claims known as the White claims.

Camps are being erected on many of these claims, and work will be pushed forward during the whole of the winter months.

At present a railway to connect the James township district with the T. & N. O. railway is urgently needed.

It was only during the latter part of the season that the attention of the public was drawn to the richness of the East branch of the Montreal river, particularly around Bloom, Obuskong and Lost lakes, but notwithstanding this, a large number of claims have been recorded and are being developed as rapidly as circumstances will permit. Messrs. G. W. Duncan and J. W. Sanderson, representing a party of Toronto capitalists, also Shields Bros., representing Windsor and Detroit people, are building camps, and are preparing to spend the winter in developing. They have brought out some very rich samples of galena and silver, and expect to be in a position to ship before the end of the coming season. These people deserve great credit for having built, at their own expense, a road from Elk lake to Bloom lake, a distance of 12 to 15 miles.

From enquiries made and the maps sent out from this office I look for a rush of prospectors to that part of my Division in the early spring.

The following table shows the moneys collected by the several Mining Recorders and remitted to the Department.

Recorder.	Mining Division.	Miner's Licenses.	Recording Fees, &c.	Total.
		$	$	$
Belyea, C. W.	Kenora	856 00	602 50	1,458 50
Bowker S. T.	S. S. Marie	2,364 00	4,681 00	7,048 00
Hough, J. A.	Larder Lake	866 50	4,097 75	4,964 25
Lemieux, F. F.	Sudbury	6,210 50	5,563 50	11,774 00
Macphail, A	Montreal R.	2,697 15	6,744 00	9,441 15
Morgan, J. W.	Port Arthur	1,730 50	3,372 90	5,103 40
McArthur, T. A.	Coleman	24,174 00	8,425 25	32,599 25
McQuire, H. F.	Parry Sound	485 00	733 00	1,218 00
Smith, Geo. T.	Temiskaming	51,683 45	79,206 85	130,890 30
Torrance, T. H.	Montreal R.	570 00	6,157 25	6,727 25
Total		91,637 10	119,587 00	211,224 10

The above table does not include the sums received and forwarded by Mining Recorders on account of the purchase of mining lands, on application being made for patents of the same.

The remainder of the revenue derived from miner's licenses and recording fees, etc., $61,173.03, was received directly by the Department at Toronto.

Diamond Drills

In February, 1907, the "S" diamond drill, of which Mr. E. K. Roche remains mechanical manager, was ordered to Kerr lake in the Cobalt district, on request of the Crown Reserve Mining Company, Limited, with the view of prospecting that portion of the lake bed purchased by the Company from the Crown, in January of the year previous. The drill continued working until about the end of May, when it was removed to St. Mary's, Perth County, to test some deposits of limestone near that place for Mr. F. G. Sanderson. Drilling was completed here in July, and the plant was returned to Kerr lake to finish there, which it did on 18th October. It was then transferred to the Rothschild property, on the northwest part of lot three in the third concession of Coleman, in which Mr. J. A. Jacobs and others of Montreal were interested. It was still employed at the Rothschild mine at the close of the year.

On the Crown Reserve property were drilled five holes, of a depth respectively of 155 feet, 140 feet 4 inches, 237 feet, 160 feet 6 inches, and 190 feet—in all, 882 feet 10 inches. The ground in places was shattered and broken. According to the manager the material penetrated in the holes included hard banded slate, conglomerate, "Keewatin" and diabase. In several of the holes excellent values of silver were struck, and the result of the drilling was to show that the property was a valuable one. The total cost of the operations was $4,258.38 or $4.82 per foot of drilling. Deducting 35 per cent., the share borne by the Department as provided by the regulations, the net cost chargeable to the Crown Reserve Company was $2,767.95 or $3.13 per foot. The gross wear and tear of diamonds amounted to $669.38, or $0.758 per foot gross.

At St. Mary's the work being in limestone was less expensive. Seven holes were put down 104, 68, 62, 70½, 22, 63½ and 85 feet respectively, the aggregate depth of drilling being 475 feet. The rock proved to be overlaid with a heavy burden of soil, gravel and boulders, difficult to penetrate, and in one instance the drill manager was obliged to abandon the attempt to reach bed rock, at a depth of 22 feet. The whole cost of the operation was $908.02 being at the rate of $1.91 per foot. After deducting the rebate of 35 per cent., the cost to Mr. Sanderson was $590.22 or $1.48 per foot. The cost of diamonds was $70.65; or per foot $0.148 gross and $0.0968 net. In putting down these holes in the limestone, 20 or 22 feet per 10-hour shift was drilled without difficulty, and as will be seen by the figures given, the wear on the diamonds was very small.

The "C" diamond drill, which is larger than the "S" plant, and capable of boring to a depth of 1,200 or 1,300 feet, as against 450 or 500 feet for the smaller drill, was in January, 1907, shipped from Paris, where it had been in use for the Alabastine Company, to Moose Mountain siding, thence to be conveyed to the neighborhood of Burwash lake in the Temagami Forest Reserve, with the intention of prospecting certain locations taken up for iron ore by Messrs. Mackenzie, Mann and Company. It proved impracticable to transport the whole of the plant from Moose Mountain to Burwash lake, consequently the drill was never actually set at work. In June, however, the outfit was sent on to Vermilion station on the Canadian Pacific railway for the purpose of prospecting a mining location on Eagle lake owned by Mr. J. E. Stanton of New York. Mr. Ralph J. Mackenzie, who had been appointed mechanical manager of the drill, went to Moose Mountain and got the plant en route for Vermilion, but before reaching his

destination left the Department's service. His place was filled by the appointment of Mr. John A. MacVicar, who took charge about the end of August. There being no settlement whatever at Eagle lake, Mr. MacVicar found it necessary to go into camp and provide his men with board and lodging. The freight charges for transporting the drilling plant were considerable, and the general cost of working was much enhanced by the remoteness of the situation, and the consequent high rates for transportation of supplies. In addition, drilling was slow, the ground proving hard and broken and the wear on the diamonds being severe. There were five holes put down, 23, 6, 22, 142, and 100 feet 6 inches respectively; total depth of drilling 293 feet 5 inches. The gross cost of the operations was $3,930.37, or $13.39 per foot, the net cost being $8.69. Loss of diamonds amounted to $1,200.98, or at the rate of $4.09 per foot. The comparatively small amount of drilling, the distance from transportation facilities and the tough and shattered condition of the rock formations encountered, combined to make the work here very expensive.

Provincial Assay Office

Mr. N. L. Turner, Provincial Assayer, reports as follows:—

The writer took charge of the work of the Assay Office on May 22nd, Mr. A. G. Burrows, the assayer previously in charge, having been transferred to other work under the Bureau of Mines.

The Provincial Assay Office was established in July, 1898, by the Ontario Government, as an aid to the mineral development of the Province. During the ten years of its existence it has been of much use not only to the public, but also to the Bureau of Mines. The fees have been kept as low as possible in order that prospectors and others may have their samples examined at a low cost. The lowness of the rates has a tendency to increase the number of samples submitted, but the fact that fees are charged prevents the office being imposed upon, which would possibly be the case if no fees were charged. Many samples are assayed and valued, which if the usual commercial fees had been charged would not have been sent in, and in this way many good finds are located. The office is well equipped with assay and analytical apparatus for testing the great variety of ores which occur in Ontario.

The past year was a very busy one for the Assay Office, indicating that there are many prospectors in the mineral districts looking for deposits of commercial value. Samples were received not only from Ontario, but also from Quebec, Manitoba, British Columbia, and the United States. As in previous years, the greater part of the samples came from the northern part of the Province. The Montreal River district furnished many good samples of silver-cobalt ore, the Cobalt district also as usual many excellent specimens. A number of good gold-bearing samples were received from the Larder Lake camp. Only one sample of all those sent in from the Cobalt district showed gold in paying quantities; this would seem to point to a comparative rarity of gold ores in that region. The search for copper bearing ores was very active during the whole year, and as a consequence many samples of good copper pyrites were examined. Many of these came from the district back of Parry Sound. In some cases the ores not only carried paying quantities of copper, but also gold. The Moose Mountain district furnished numerous samples of iron ore of very good quality, as also did North Hastings. There are a number of iron ore deposits in the latter region but the lack of good transportation facilities prevents their development. From the Sudbury district a large number of pyrrhotite samples were received. These with one or two exceptions contained nickel, most of them carrying a very small amount, but others had the metal in paying proportion. From other parts of the Province gold, lead, zinc, molybdenum and other ores were received, as well as limestones, clays, feldspar, fluorite and corundum.

The total number of samples submitted for examination quantitatively was 1,389, and for qualitative examination and identification 169. Fees were collected to the amount of $1,635.56, which were transmitted to the Bureau of Mines. Work to the value of $759.60 was performed for the Bureau of Mines, making the total value of the work performed during the year $2,395.16.

The following list of determinations will show the laboratory work for the year:—

	Assays for Public.	Assays for Bureau.	Total.
Gold	617	177	794
Silver	462	345	807
Copper	227	6	233
Cobalt	35	69	104
Nickel	75	27	102
Manganese	1	1	2
Molybdenum	2		2
Zinc	24		24
Lead	39		39
Platinum	6		6
Arsenic	7	16	23
Tin	2		2
Mercury	1		1
Bismuth	1		1
Chromium	1		1
Total	1,500	641	2,141

	Analyses for Public.	Analyses for Bureau.	Total
Metallic iron	130	19	149
Ferric oxide	13	3	16
Ferrous oxide		1	1
Alumina	19	3	22
Silica	20	3	23
Lime	16	4	20
Magnesia	16	4	20
Sulphur	57	6	63
Potassium	6	1	7
Sodium	6	1	7
Phosphorus	48		48
Titanium	32		32
Carbon in graphite	2	1	3
Fixed carbon	13		13
Ash	13		13
Volatile combustible	13		13
Moisture	16		16
Miscellaneous	24	6	30
Total	444	52	496

Total assays	2,141
" analyses	496
" identifications	169
Total determinations	2,806

Work for the Pubic

(1) Issuing reports, consisting of assays, analyses and identification of samples submitted for testing.

(2) Supplying information, where possible, to owners of mineral lands, who desire to know of probable purchasers, and also advising as to uses, values, etc., of their minerals.

(3) Sending typical samples of ores and minerals to prospectors who desire to use them for comparison.

Work for the Bureau of Mines

(1) Analyses and assays of samples of minerals and ores collected by the Government geologists during their summer explorations.

(2) Assay of samples from the Government claim inspectors for the Cobalt and other districts.

(3) Making check analyses and assays on ore shipped from the O'Brien mine to the Copper Cliff smelter.

(4) Checking the sampling of ores shipped from the O'Brien mine to the Deloro Mining and Reduction Company.

(5) Making check assays and analyses on the ore shipped to Deloro.

(6) Calculating results of sampling and assaying ores shipped to Deloro.

During the year considerable new apparatus was put in the office. A disk grinder with suitable power was installed which greatly hastens the work of grinding samples. A new combination assay furnace was placed in the assay room. and is giving entire satisfaction.

The methods of analysis and assaying used are the standard methods. In the case of high grade silver-cobalt ores scorification is used in preference to other methods.

Ordinary gold and silver samples are assayed by the crucible method, each sample being assayed in duplicate, so that the chances of error are minimized.

Cobalt and nickel, by the electrolytic method, using the nitrite separation. Considerable experimental work has been carried on in regard to the estimation of these two metals with very encouraging results.

Copper, by the electrolytic and cyanide methods.

Lead, by the molybdate method.

Notes

In sending in samples it is desirable to have them no more than three pounds in weight. All samples are sampled down and ground to 100-mesh, and where necessary, finer. Wet samples are dried at 100 degrees C. and analysis reported at that temperature. Circulars of rates and mailing bags are supplied to those desiring to send in samples for examination. To insure a prompt report all fees must accompany samples.

Samples brought to the office will be examined free of charge.

One assistant, Mr. H. C. Barlow, was employed during the entire year, and during the summer months Mr. W. J. Embury was also employed, both of whom did excellent work.

SUMMER MINING CLASSES

BY E G R ARDAGH AND W MALCOLM

It was thought expedient by Mr. T. W. Gibson, Deputy Minister of Mines, to confine the work this year almost entirely to the Temiskaming country, including in that area the Larder lake and Montreal river regions. The results of the classes shew that with the exception of those held in one or two localities the choice of the field was well made, for not only was the attendance all that could be desired, but the interest shown by those present was of the greatest, particularly in those districts where energetic prospecting was being carried on.

Methods of Work

A few words setting forth the scope and purpose of the work may not be out of place here. The purpose is in its nature two-fold. First, the imparting of information enabling the prospector and miner to search intelligently for valuable mineral, and, on having discovered the same, to recognize it; and secondly, though indirectly, to develop the mineral resources of the Province.

With these ends in view we considered it advisable not only to distribute mineral samples, describing their associations and the simple tests by which they can be recognized, but also to deliver several lectures, accompanied by lantern slides, fundamental in their nature, or especially applicable to the particular locality. The minerals distributed were for the most part the more commonly occurring ones, but in addition to these samples of a few rarer economic minerals were given out; minerals such as tinstone and cryolite, which it is hoped will be discovered in Ontario, and others such as niccolite and smaltite, which prospectors are eagerly looking for in certain districts. From thirty-five to forty species of mineral were studied at each camp, common field tests being applied and a few remarks made concerning the composition, occurrence, distribution, uses and value. Every man present received a sample of each mineral, and, to wrap it in, a printed paper bearing the name of the mineral and a few words relative to its value, uses and composition. In order to utilize the daylight the minerals were distributed early in the evening, and at several camps in the afternoon as well, usually out of doors. The lantern lecture was delivered afterwards, and for this a commodious room was always placed at our disposal.

Bessemer

In accordance with instructions we held our first class at Bessemer, the camp of The Mineral Range Iron Mining Company, five miles east of L'Amable in Hastings county.

Mr. H. C. Farnum, general manager of the company, whom we met on the train in company with Mr. Gordon, vice-president, kindly had our baggage put off at the company's siding, about a mile south of L'Amable, and conveyed by their own railway, "The Bessemer and Barry's Bay," to the camp. We were hospitably received and housed by the management.

The Company has in its employ in the neighborhood of one hundred men, of whom more than one-half are English-speaking. Of the latter we had approximately fifty, the average attendance per night being thirty-one. We opened the class on Saturday, May 11th, and closed it on Thursday, May 16th.

Mining operations are being actively carried on at two of the Company's mines, viz.: Number Three Mine and Number Four Mine; from these a very good quality of magnetite is being shipped. Analyses of two ten-carload shipments shewed in one case iron 60 per cent. and phosphorus .014 per cent.; in the other case iron 57.1 per cent. and phosphorus .013 per cent. The company has additional ore bodies from one of which a considerable quantity of magnetite was shipped last winter when the snow made

transportation possible. The railway line has been surveyed and partially graded to this deposit, but the management has not yet had sufficient time to lay steel beyond Number Four mine. The company has also on its property several outcrops of fine-grained white marble, which they hope upon examination will prove valuable.

From Bessemer we shipped in for next year's work a quantity of magnetite, marble and talc.

On Friday, May 17th, Mr. Bingham, Secretary of the company, to whom we are indebted for many kindnesses, took us to the Central Ontario railway on the track velocipede, sending our mineral boxes, etc., by road to L'Amable on the company's waggon.

Latchford

Arriving in Toronto the same evening we caught the Cobalt special, reaching Latchford, the gate-way to the Montreal River region, next morning. Owing to the late spring, the ice had just gone out of the Montreal river, and the small army of prospectors who had been waiting at Latchford for the ice to break up were already setting out in numbers every day of the week we were there. Each day saw numerous fresh arrivals, but these for the most part remained in the town only long enough to complete their outfits before going up the river. The consequence was that a number of men were in attendance for only one or two days; this accounts for the total of seventy, and the comparatively small daily average of twenty-three. In many cases we made up complete sets of minerals for those who could not remain till the end of the week, or who had missed the first day or two of the class. Owing to their eagerness to reach the field of action, many of the prospectors did not attend any of the classes; however, the great majority of those who were present exhibited intense interest in the work. The classes were opened in Brown's hall on May 18th, and closed on May 25th.

Cobalt

On May 27th we commenced a class at Cobalt in the Reading Camp Association's room, which the management kindly placed at our disposal. This room was invariably crowded with men whose time might otherwise have been far less profitably spent. We cannot but recognize the fact that the Association is carrying on a wonderfully useful work and consider it well worthy of the attention of those philanthropically inclined. We are also indebted to Mr. J. G. McMillan for comfortable quarters when in Cobalt, not only during this week but later when we repeated our class there in July.

Cobalt being one of the most active mining centres in the Province, we had, as might be expected, largely attended classes both in the afternoon and evening. We estimated the total attendance at one hundred and thirty, the daily average being seventy.

Through the kindness of Mr. E. L. Fraleck of the Cobalt Lake Mining Company, we collected, by dint of hard labor, about one hundred and fifty pounds of niccolite from the dump at number three vein; a large quantity of cobaltite and smaltite was also presented to us by Mr. J. W. Evans, M.E. All of this and also some cobalt bloom was shipped in for next year's work. The class in Cobalt was closed on June 1st.

Haileybury

On Monday, June 3rd, we opened a class at Haileybury in the Mining Commissioner's room and kept it open till June 8th inclusive. The average attendance there was only thirteen, and the estimated total thirty-five.

New Liskeard

In the matter of attendance New Liskeard, where we held a class the week following, shows up no better. Average fourteen, total estimated at thirty.

Englehart

In response to an earnest request from Mr. Williams Hugh, Crown Lands Agent at Englehart, we decided to open a class there on June 17th, instead of holding one at Tomstown as first suggested. Mr. Hugh made arrangements which enabled us to use the schoolhouse, and, largely through his efforts, a good attendance of interested men resulted, despite the fact that Englehart is some distance from the mining and prospecting field. The average daily was twenty-two, and the total was estimated at forty-five. The class was closed on June 21st, a day before the end of the week, in order to allow us extra time to reach the Larder Lake country for which we set out early on the 22nd.

Larder Lake

Having estimated the comparative cost of entering the Larder Lake district by waggon and by canoe, we concluded that the latter would entail far less expense; so we decided to take that route though the labor connected with the trip was by no means inconsiderable. This may be the more readily appreciated when one considers that there are eleven portages to be made. It was of course out of the question for us to take the projection lantern, and we even made an estimate of the probable attendance, and counted out the minerals to conform to this in order to avoid unnecessary weight.

We entered Larder Lake early on Monday morning, June 24th, and, upon looking the situation over, we concluded Larder City to be most suitable place for gathering the prospectors about us. Notices were posted up at the foot of the lake, the Narrows, Spoon's Bay, etc., points at some distance from Larder City, so that all who possibly could reach the class might be notified.

From the point of view of attendance and enthusiasm the Larder City class ranks among the first. The daily average was thirty-nine, and the total estimated to be seventy-five.

There were numerous prospectors scattered around the lake and through the country back from the shores, and there is no doubt the number would have been far greater had it not been for the flies and also the excessive cost of transportation, five dollars per hundred pounds, which raised supplies to a price almost prohibitive to men of ordinary means.

The class was closed on Friday, June 28th, and early Saturday morning, with considerably lightened packs, we set out on our return trip, reaching Tomstown on Sunday.

Giroux Lake

The next class was opened at the Foster mine near Giroux lake on Tuesday, July 2nd. There we hoped to reach not only the men in the Foster mine camp, but those at the University Mine, a few from other neighboring camps, and also from the construction camp for the railway spur line. In this we were not disappointed. Almost all the men in the mining camps in the immediate neighborhood were English-speaking. From the two large camps, the Foster and the University, about half the men attended. The management kindly placed at our disposal for the lantern lectures their commodious dining hall, in which we were able to accommodate the large class quite easily.

The average attendance was thirty-eight, the total about fifty-five. The class was closed on Saturday, July 6th.

We are indebted to Mr. Adler of the Foster mine for a keg of cobalt bloom, and to Mr. Flynn of the University mine for a large quantity of chalcopyrite. This was all shipped in for future distribution.

Cobalt Again

Arrangements had been made with Mr. Brigstocke of the Drummond mine by which a class should be held at that camp the week following, but owing to the miner's strike this was out of the question. This contingency, for the suddenness of which we were quite unprepared, threw our plans into some confusion, and forced us at the last moment to make new arrangements. We decided that it would be better for us to commence a class in Cobalt without some notice than anywhere else, consequently we opened there the evening of the day the strike was declared, Monday, July 8th.

The afternoon sessions were most successful; the attendance at the evening classes was however scanty, owing to the suppressed excitement possessing the crowds of strikers gathered in the centre of the town. The average attendance was fifty-seven, the estimated total one hundred and twenty. The class was closed on July 13th.

Elk Lake

On the Monday following we set out for the mouth of Bear river (Elk lake P.O.), in James township, about fifty-five miles above Latchford on the Montreal river, arriving late that night.

As in the case of Larder Lake, we left the projection lantern behind. The settlement at Elk Lake P.O. is a village of tents, of which we counted thirty-five on the Reserve shore and eighteen on the opposite bank. There are also numerous camps back from the river, and many of these sent contingents to attend the classes. Owing to the personal interest which everyone took in prospecting, we had the largest and most enthusiastic class of the season. The average attendance was seventy-six, and the total was estimated at one hundred and thirty. The class was opened on Tuesday, July 16th, and closed on Saturday, July 20th.

Many men brought in mineral specimens and also samples of rock for identification.

Camp Coghill

A letter from Mr. J. M. Coghill, of Camp Coghill, Montreal river, on the line between the townships of Auld and Lundy, asked us, if we possibly could, to hold a class there. This we decided to do. Although the class was not large, owing to the paucity of prospectors in the neighborhood, the interest exhibited was keen. Work was commenced on July 22nd, and ended on the 26th.

Latchford's Second Class

After consulting with the mayor, Mr. J. J. McNeill, who expressed an desire that we should hold a class in Latchford, and who offered us the schoolhouse for the lantern lectures, we decided that we could hardly do better elsewhere, owing to the fact that the flies had driven so many of the prospectors out of the woods, and that a number of these men were still awaiting in Latchford till the winged pests had thinned out somewhat before re-entering the field.

The attendance this week was much better than at the class held there in May. The average was thirty, the estimated total fifty.

Notes

Probably in no other Canadian mining district were gathered together so many men who have prospected or mined in the world's most famous camps. Here one meets men from the gold fields of Kalgoorlie, the diamond mines of Kimberley, the tin deposits of the Straits Settlements, and all the mining centres of North America. Many of these men attended the classes in addition to Canadians, and not infrequently expressed the wish that other countries would assist the prospector by classes similar

to those held in Ontario. Many prospectors also attended who had been present in former years, several of whom mentioned that they had been assisted immensely in their work by the information imparted, and two successful men stated that the discoveries they had made were rendered possible in a great measure by the knowledge gained at these classes.

The number of college men, undergraduates as well as graduates, of universities and technical schools, who are assisting in the development of this new country, both by prospecting in new fields and in the development of those now firmly established, is quite remarkable, and great credit is due the Canadian college man for the part he is playing in the opening up of this new country, a country vast in possibilities as in area.

We estimate the number of mineral samples distributed to be in the neighborhood of twenty thousand.

The table which follows summarizes the attendance at the various classes:—

PLACE.	DATE.	Average Daily Attendance.	Estimated Total Attendance.
Bessemer	May 11th-May 16th inclusive	31	50
Latchford	May 18th-May 25th "	23	70
Cobalt	May 27th-June 1st "	70	130
Haileybury	June 3rd-June 8th "	13	35
New Liskeard	June 10th-June 15th "	14	30
Englehart	June 17th-June 21st "	22	45
Larder City	June 24th-June 28th "	39	75
Foster Mine	July 2nd-July 6th "	38	55
Cobalt	July 8th-July 13th "	57	120
Bear River	July 16th-July 20th "	76	130
Camp Coghill	July 22nd-July 26th "	13	20
Latchford	July 29th-August 2nd "	30	50
	Total	426	810

MINES OF ONTARIO

BY E T CORKILL

Gold Mines

There were more gold mines in operation in Ontario during 1907 than in 1906, although the number of stamp mills in operation and the production of gold were practically the same. Most of the properties in operation were engaged in development work. In northwestern Ontario the greatest activity was in the Upper Manitou lake country, where the Laurentian mine for most of the year carried on both mining and milling. The Victory, Paymaster and Detola, all in the vicinity of Gold Rock, were doing development work, while the Minnehaha, at the northeast end of lake Minnehaha, comprising claims S V 434 and S V 435, began work late in the year.

At Sturgeon lake considerable prospecting was done, and at the St. Anthony gold mine the mine and mill were steadily run during the latter part of the year. On Lake of the Woods little was done. On Eagle lake the mill at the Grace mine was completed. The mines of the Northern Light Mining Company were inactive.

In the Michipicoten district the Algoma Power Company have installed at the High Falls of the Michipicoten river a power plant with 600-h.p. turbine and 450 kilowatt generator. This power is being used by the LePage Gold Mining Company, which is operating the Grace mine. A number of other prospects in the district are being developed, of which the Golden Reed and the Braddock were in operation at the time of my inspection in October, 1907.

In the vicinity of lake Wahnapitae, the Crystal gold mine is being re-opened after having been closed down for some years.

Development of the gold properties in eastern Ontario was carried on in 1907 in about the same manner as at any time during the past ten years. The Golden Fleece Mining Company during the winter erected a 10-stamp mill and ran it for a couple of weeks, when it was closed down and all work at the mine ceased. Development work is being done on a number of properties, consisting of the Big Dipper, Boerth, Sophia and Pearce.

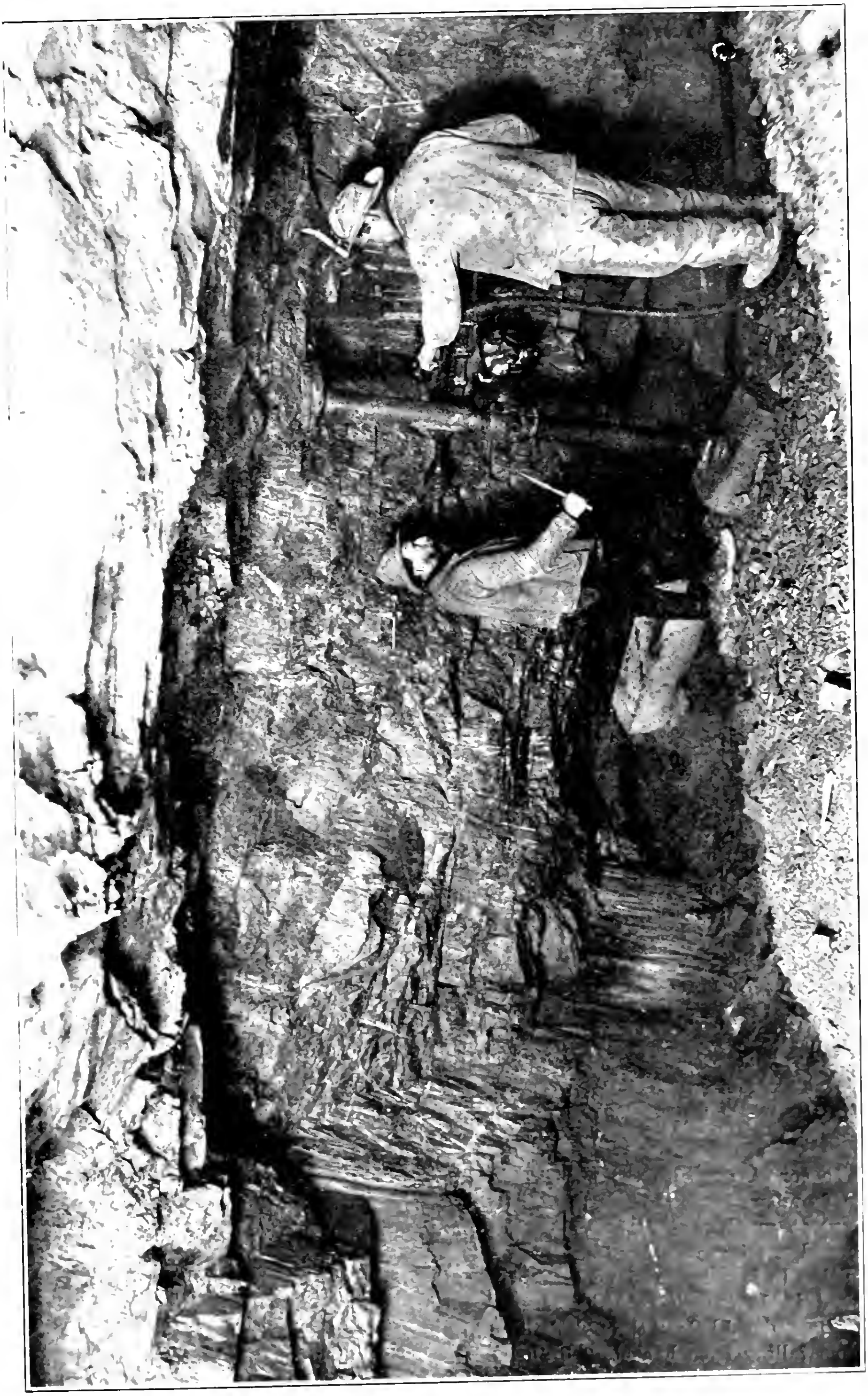
Although a couple of stamp mills have been erected at Larder lake, the development done on any of the properties is small, and until systematic work has proven the value of the camp, it will be regarded largely from a speculative point of view.

Iron Mines

Prospecting for iron in western Ontario is still being carried on extensively both by test pitting and diamond drilling. The reported discoveries of bog ore along the main line of the Canadian Pacific railway at Niblock station, have attracted considerable attention. The closing down of the blast furnace at Port Arthur caused the Atikokan Iron Company's mine at Atikokan to cease operation in the fall of 1907, after having been in operation for 6 months, shipping about 100 tons of ore per day. The Helen mine at Michipicoten is still the largest shipper in Ontario, and is at present the only producer of hematite. The slump in the iron market in the United States had a deterrent effect on the production of iron ore from Moose Mountain, so that up to the present no ore has been shipped, although a considerable tonnage is mined and stock piled. In eastern Ontario the Wilbur iron mine on the Kingston and Pembroke railway is making daily shipments of 150 to 200 tons to the furnace at Sault Ste. Marie, Ontario. The daily output from the Mayo mine, operated by the Canada Iron Furnace Company, at Bessemer, is being gradually increased; at present about 150 tons per day is being shipped.

Copper and Nickel

Not much activity is noticeable in the production of copper outside of the Canadian Copper Company and the Mond Nickel Company. A new copper smelter has been erected at Thessalon, but no ore has as yet been smelted at it. The fall in the price of this metal has naturally had a somewhat discouraging effect.



Laurentian gold mine, 200-foot level stope.

The company operating the Bruce mines got into financial difficulty in 1907, and all work at the mines ceased. Smelters have been erected at Sturgeon Falls and Trout lake at a considerable expenditure for the purpose of smelting copper ores as well as the cobalt-nickel-silver ores of the Cobalt camp. These furnaces have, however, not as yet entered the market as buyers of any kind of ore.

The nickel-copper mines in the Sudbury area are maintaining production on about the same scale as formerly, and improvements are being prosecuted energetically at the smelting plants of both the Canadian Copper Company and the Mond Nickel Company. The former company have, during the last six months made additions to their smelting capacity by erecting a new converter building in which ten converter stands have been built, five being already in commission. A new mixing and relining plant for the converters has been installed in this building.

The Mond Nickel Company are developing a water power in the township of Lorne, on the Vermilion river, with the view of using electric power for driving all their machinery both at the smelter and at the mine. At the Whistle property on the north nickel range, work has been carried on during the year in diamond drilling and shaft sinking.

The Worthington mine, which has been closed for some years, has been pumped out and some shipments of ore made.

Other Minerals

The production of iron pyrites in Ontario while yet small and confined to three localities, the Helen mine, Rib lake and Hastings county, will probably be increased with the completion of the Winnipeg-Fort William section of the Grand Trunk Pacific. Some very promising developments in iron pyrites were made last year at Goudreau lake in the Michipicoten district.

The mica industry received a severe set back in the fall of 1907 owing to the slump in electrical business. The orders for new machinery with the electrical companies were nearly all cancelled, so that no demand was made for mica except for repairs and renewals. The price of the larger sizes of mica has not fallen in proportion to that of the small sizes.

Work has recently been started on the two graphite properties at Black Donald and Port Elmsley. Certain changes have been made in the mill and experienced graphite men put in charge of them.

The silver mines of the Cobalt camp have been fully dealt with in Chapter II of Part 2 of the Sixteenth Report of the Bureau of Mines, and it is therefore unnecessary to deal with them here. The information contained in that Report is brought up to the date of the present volume, and those specially interested in that district are referred to the Report mentioned for full details. The mines were visited and inspected to see that the regulations provided by the Mining Act regarding the working of mines were observed. A number of investigations were held into the causes which resulted in fatal accidents at some of the mines.

Accidents and their Causes

In connection with these accidents, there are a number of points to which it has been found necessary to call the attention of mine managers. The most important is the great number of accidents caused by the premature explosion of an explosive, either dynamite or gelignite. In 1907, there were 35 mine accidents in Ontario, resulting in injuries to 41 men, 22 of whom were killed. Of these 18 were killed below ground in 15 casualties. The causes of death were as follows: 2 men killed while reloading missed hole, 2 through drilling into missed hole, 5 by picking into an explosive, 4 from falling from bucket, 3 by being caught in machinery, 1 by being struck by a car falling down shaft, 3 by being struck with falling rock, 1 by falling down shaft,

and 1 by falling from crusher floor to ground. It will thus be seen that 9 of the men, or 50 per cent. of the number killed underground met their death through an explosion of dynamite or gelignite, which are the only two explosives used in Ontario.

Dealing with the causes of accident, we find 2 men killed in reloading missed holes. Such accidents show negligence on the part of someone, as there is no excuse for an accident happening in reloading a missed hole. The Mining Act, section 164, subsection 10, states that a charge which has missed fire shall not be withdrawn, but shall be blasted. This is quite safely done if the miner understands his business, and if he does not, the superintendent of the mine is responsible for putting an incompetent man to handle explosives.

Two other men were killed during the year through drilling into a missed hole. The same section of the Act directs that all missed holes shall be reported to the mine captain or foreman in charge of the next shift if the hole has not been blasted. This is a most essential point, but no missed hole should even be left for the next shift to blast; but should be blasted as soon as found, and all old bottoms should be examined before work is done near them to see that there is no explosive left in them. The practice of starting a new hole in the bottom of an old one because it is an easy place to begin, should not be permitted under any circumstances, and the miner who follows this practice, or the foreman who allows it, is simply courting accidents.

The most prolific source of accidents from explosives is picking into them either in old bottoms or lying loose in the muck, 5 men having been killed during the year from this cause. In shaft sinking there is considerable danger from this source which is unavoidable, and this very fact should lead to increased caution. The driller firing a round of holes in a shaft should be very particular in counting the reports, and if there are any reports short this should be reported to the next shift, who should also be notified just where the holes were drilled, so that in mucking out due caution may be used in picking up the bottom. The old theory held by some miners that if the exploder is taken out of the hole there is no danger is a misconception, and miners should be taught differently. Superintendents and foremen are much to blame for accidents of this kind who fail to instruct the men under them properly, or who neglect to see that the men exercise due care. Accidents from picking into loose explosive which has got into the muck from a cut-off hole are difficult to guard against. A good precaution when dynamite is used is either to take the wrapper off the dynamite cartridge or to slit it so that if the dynamite does get into the muck it disintegrates, and is so scattered about that there is not sufficient in one place to do any damage. Another safeguard is to keep the muckers from using the pick too strenuously. It is as effective when mucking in drifts to use the pick for pulling the muck down, as to sink it up to the eye, to the great danger of the workman. The latter practice is simply energy uselessly expended.

Another source of accident is the introduction of an explosive with which the men are not familiar. This is especially true in the cold weather when the explosive has to be thawed. Dynamite is the explosive to which long use has accustomed all miners. When thawing it they gauge its readiness for use by its pliability. Other explosives, such as gelignite, even when pliable may not be properly thawed, and in fact the latter is quite soft when partly frozen. In the condition near its freezing point, gelignite is most dangerous, as is also dynamite. Superintendents should see that all explosives are in the thawing house exposed from 4 to 6 hours to a temperature of 85 to 90 degrees F. If warm water is used, the temperature of the water should not be above 125 degrees F. Care should also be taken that the explosive should not be removed from the thawing house in cold weather until the miner is ready to load his holes.

There are other classes of accidents which contribute to the formidable total of deaths and which are often ascribed to unavoidable sources of danger inseparable from the business of mining. The soundness of this contention cannot be admitted. It is not difficult to indicate directions in which carelessness, neglect of regulations, or the permission of practices fruitful of danger leads to accidents which the superin-

tendent in whose mine they occur seeks to class as unavoidable. The practice of riding in buckets, which contributed 4 to the death roll in 1907, is strictly prohibited by the Mining Act. The mines in Ontario are for the most part shallow workings, and there is consequently no excuse for men riding to the surface on buckets or skips when proper ladder-ways are provided, as is the case in practically all the mines. Such accidents are nearly all due to negligence on the part of the superintendent in enforcing this rule. Some superintendents try to excuse themselves by saying it is impossible to prevent men riding on the bucket. Such excuses are fallacies and only an attempt to shirk responsibility. In a large number of mines in the Province such practices as riding on the bucket or skip are unknown.

The necessity of guarding shaft entrances at all levels of the mine cannot be too much emphasized. Not only should superintendents have all levels so guarded, but they should also see to it that the guard rails are always kept in position when the shaft is open. A careful superintendent, one who tries to guard against all possible accidents and is always on the alert to prevent them, will in time intuitively instil into the minds of his men a like degree of care and regard for their own safety, while a superintendent who is careless and reckless about the work of the mine can only expect his men to be the same, and has himself to blame if his men do foolhardy things.

I.—Northwestern Ontario

Upper Manitou Lake District

The gold mines of Upper Manitou lake were the scene of considerable activity during the year. The property that has occupied the largest share of attention is the

Laurentian Mine

The location and way of access to this mine have been fully described in former Reports of the Bureau of Mines. It was in active operation during 1907 and the 20-stamp mill was worked for a great part of the year. The property is operated by the Anthony Blum Gold Mines, Limited, under the holding company known as the Imperial Gold Mines, Limited. Most of the work during 1907 consisted in sinking the main shaft from the 200-foot to the 300-foot level, cutting a station on this level and drifting north 110 feet and south 30 feet. A short cross-cut has been driven west 75 feet from 15 feet north of the shaft. On the second level the raise has been put through north of the shaft to the first level, and some stoping done just above the level. On the first level south of the shaft a raise has been put up 50 feet, 15 feet from the shaft. A drift has been made here south from the shaft 60 feet, and some stoping done. North of the shaft a raise has been put up 40 feet, and a body of ore stoped out 30 feet in height by 30 feet in length. The vein material on which the drifts have been run consists of quartz lenses through a vein filling of slate and chlorite schist, which is apparently an altered form of the greenstone.

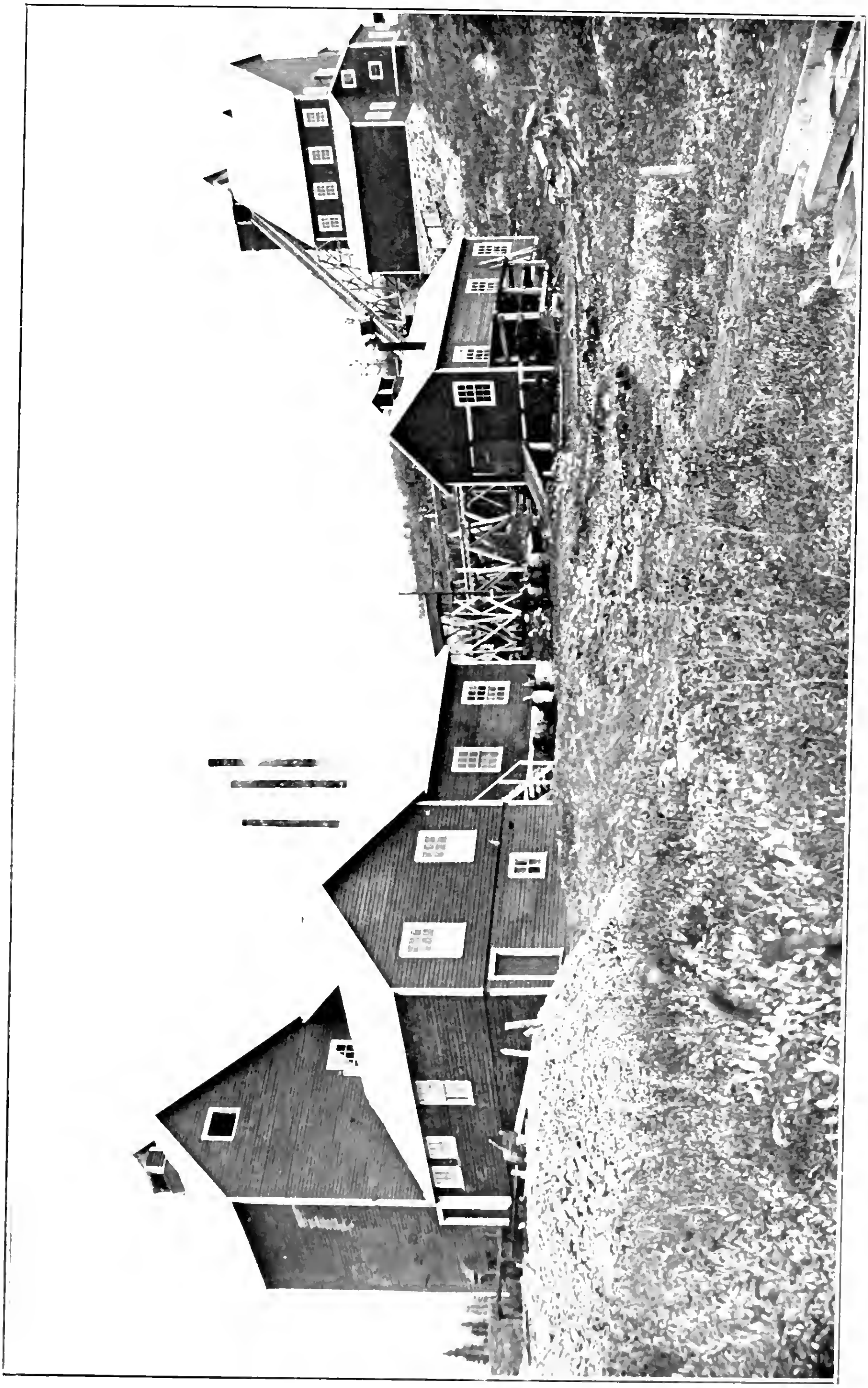
A number of minor alterations have been made in the mill during the year. A 5-inch pipe line has been laid to Upper Manitou lake, a distance of about three-quarters of a mile and a pumping plant installed on the shore of the lake. The pipe line has been laid about 4 feet under the surface so as to be below the frost zone.

Mr. R. B. Nickerson is superintendent, employing an average force of 30 men.

Paymaster Mine

The Northern Development Company, owners of the Paymaster mine, which is on mining location H W 29 and is situated about one half mile southeast of the Laurentian, was engaged during the year in development work. The main shaft has been sunk to a total depth of 275 feet. On the 200-foot level drifts have been driven north 135 feet and south 75 feet. The attention of the management was called to the necessity of having the shaft properly timbered and ladder-way put in.

Mr. Geo. Thow is superintendent, employing a force of 12 men.



Laurentian gold mine; shaft house and stamp mill.

Detola Mine

The Detola Development Company is developing a quartz vein on mining location H W 411, which lies about one-half mile east of the Laurentian mine. A shaft has been sunk to a depth of 60 feet on the vein, which carries considerable iron pyrites. It has a strike north and south cutting the greenstone.

A 25-h.p. boiler and hoist have been installed and new camp buildings constructed on the shore of Mud lake.

Mr. Bliss is president of the company, and is in charge of operations.

Victory Mine

Mining location McA 28, lying about one-half mine northwest of the town of Gold Rock and formerly known as the Neepawa, is being worked by the Manitou Mines, Limited.

Mr. H. D. Alston is managing director and Mr. J. Beck, superintendent. The shaft was originally sunk to a depth of 100 feet, and at the time of my inspection, had not been put down any farther. Considerable surface prospecting had, however, been done on other parts of the location. A new plant was being installed consisting of two 50-h.p. return tubular boilers, an $8\frac{1}{4} \times 10$-inch Lidgerwood hoist and straight line compressor. Boiler house, blacksmith shop and camp buildings had been constructed. Instructions were given to have the old timbers at the collar of the shaft removed and replaced with new ones.

The vein has a strike of 20 degrees east of north, and consists of lenses of quartz occurring in a slaty formation or vein filling in the greenstone. This slaty formation is an altered variety of the greenstone.

Eagle Lake District

With the exception of some prospecting, no work was done on the veins in this district during 1907, save at the Grace mine. Here a mill was erected during the spring of 1907 and some ore milled. But little development work has, however, been done at the mine beyond what has been described in former Reports of the Bureau of Mines.

Lake of the Woods District

There was less activity in mining in the Lake of the Woods district during 1907 than any year since the boom following the discovery of gold there. The properties on which anything was done during the year have been operated very irregularly, so that really no systematic work was done on any of them. On Shoal lake the Olympia and Golden Horn were the only mines at which work was attempted. East of Lake of the Woods and Whitefish bay, the Empire Gold Mining and Milling Company have during the winter of 1907 been developing their property. A mill run was made to test the value of the ore.

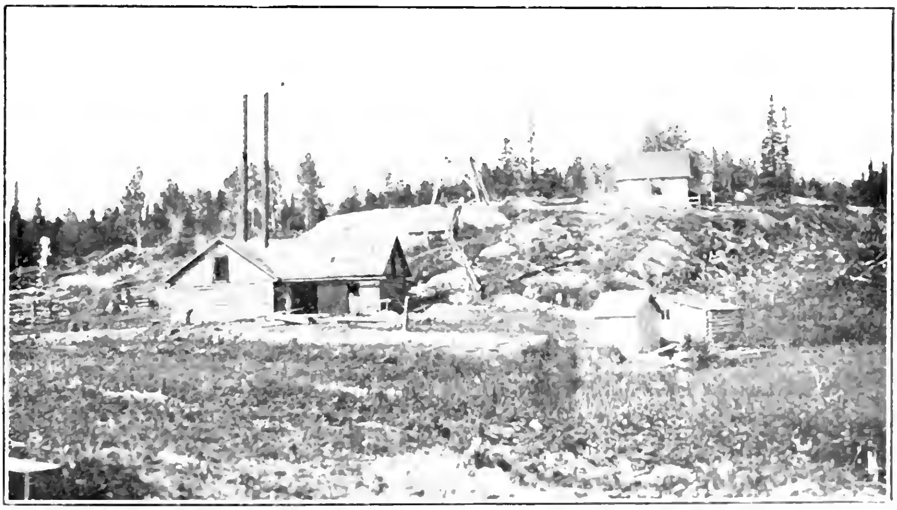
Sturgeon Lake

Considerable prospecting was done in the vicinity of Sturgeon lake during 1907.

St. Anthony Gold Mine

Chief among the properties operating was the St. Anthony gold mine. This mine has up to the present been compelled to take in supplies by a long canoe route from Osaquan on the main line of the Canadian Pacific railway. The Superior branch of the Grand Trunk Pacific railway passes within four miles of the south end of Sturgeon lake. This will necessitate a road of that length to the lake, from which place the Company's tug can haul the supplies direct to the mine. In 1907 the St. Anthony mine was closed down in the spring, but reopened in August with Mr. J. Steele in charge of operations.

Paymaster gold mine.



Victory gold mine, Upper Manitou lake.

No. 2 shaft on which the shaft house is erected, is sunk vertically to a depth of 100 feet. The vein dips to the west, so that at the 100-foot level a cross-cut of 30 feet was driven to intersect the vein. From here drifts have been run north 156 feet, where a raise has been put through to the surface. This drift has been extended farther north on the vein a distance of 33 feet and a cross-cut driven west 65 feet. To the south of the shaft a drift has been driven on the vein from the cross-cut south 67 feet, then east 35 feet and from here south 150 feet to the No. 3 shaft. During the last year an open cut has been taken out from the shore of Couture lake on the south end of the vein for a distance of about 150 feet, along the vein. This open cut at its north end is about 25 feet in depth and is in places 20 feet in width.

The plant consists of two 80-h.p return tubular boilers, a 9-drill compound steam, duplex air compressor, with jet condenser, a 125-h.p. engine, small engine for electric light plant, and small engine for driving the machinery in the machine shop. The machine shop is fully equipped with lathe, planer, drills, etc. A 10-stamp mill has been installed with full equipment. The pulp from the plates is run over a Wilfley table and Frue vanner. The pumping plant to supply water for milling purposes is situated on the shore of Couture lake, consisting of a No. 5 Cameron, a Gardiner duplex and a small Northey. A hoist with 10 × 12-inch cylinders and 3-foot drum is used for hoisting from the main shaft.

The rock formations in the area adjoining the mine were described by Prof. Miller in the Twelfth Report of the Bureau of Mines. It has, however, been proved by development work in the mine that the granite contact with the green schists which cuts across the vein between No. 2 and No. 3 shafts, has a uniform dip to the east under the green schists of about 45 degrees.

Douglas Mine

The Douglas Mining Company were engaged in development work on their holdings, which include T B 5, 6, 7 and P 6 and 7. These locations lie east of Belmore bay, which is a bay off the northeast arm of Sturgeon lake. Mr. C. S. Gzowski is president of the company, Mr. Daggett, secretary-treasurer, and Jas. Atwood, manager.

The Belmore Bay Gold Mining Company were engaged in the winter of 1906 sinking a shaft on H W 746 east of Belmore bay. At the time of my inspection in September, 1907, no work was being done at the property.

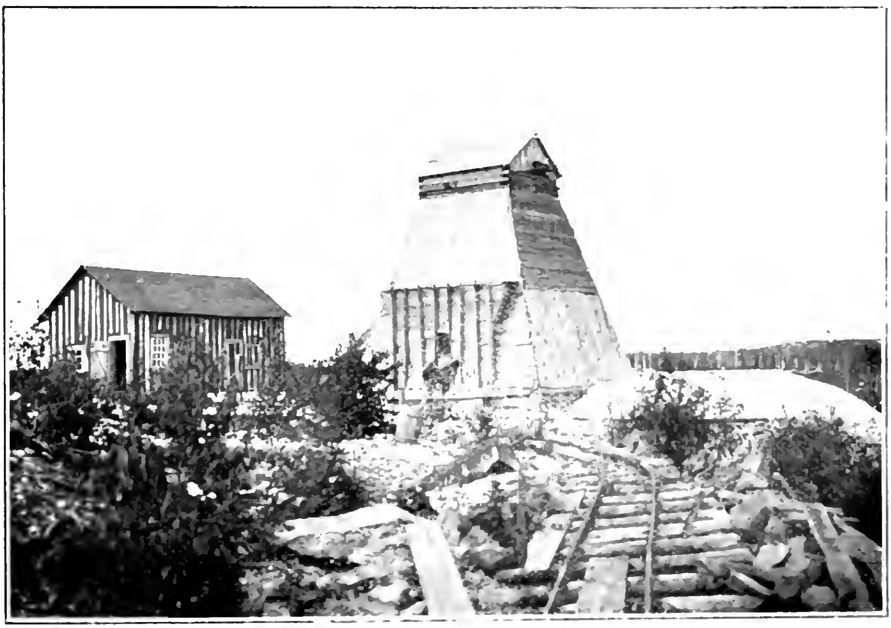
Northern Pyrites Mine

The Northern Pyrites Company were operating during 1907 an iron pyrites mine on locations H W 715 and 716, on the north shore of Big Vermilion lake. Access to the mine in summer time is by a 9-mile portage from Dinorwic to Big Sandy lake, thence by steamer across the lake 8 miles to Blackface portage, one-quarter mile in length, thence by steamer on lake Minnetakie 26 miles to the chutes, where there is a portage of 400 feet, thence by Abram lake to Pelican lake, and along Vermilion river to a portage three miles in length to the mine.

The main shaft has been sunk to a depth of 120 feet, with the first level at 86 feet. From the first level a cross-cut of 50 feet has been driven and a drift 25 feet in length. At the time of my inspection the shaft was being re-timbered. It was sunk in the hanging wall of the deposit, and the vein was cut at a depth of 80 feet, the vein dipping at 60 degrees. The best pyrites is found near the foot wall about 100 feet from the shaft. A pit sunk about 150 feet from the shaft shows pyrites of very high grade. The outcrop on the shore of the lake some 500 feet west was the means of making the discovery, the country being very heavily covered with subsoil. The vein strikes northeast by southwest.

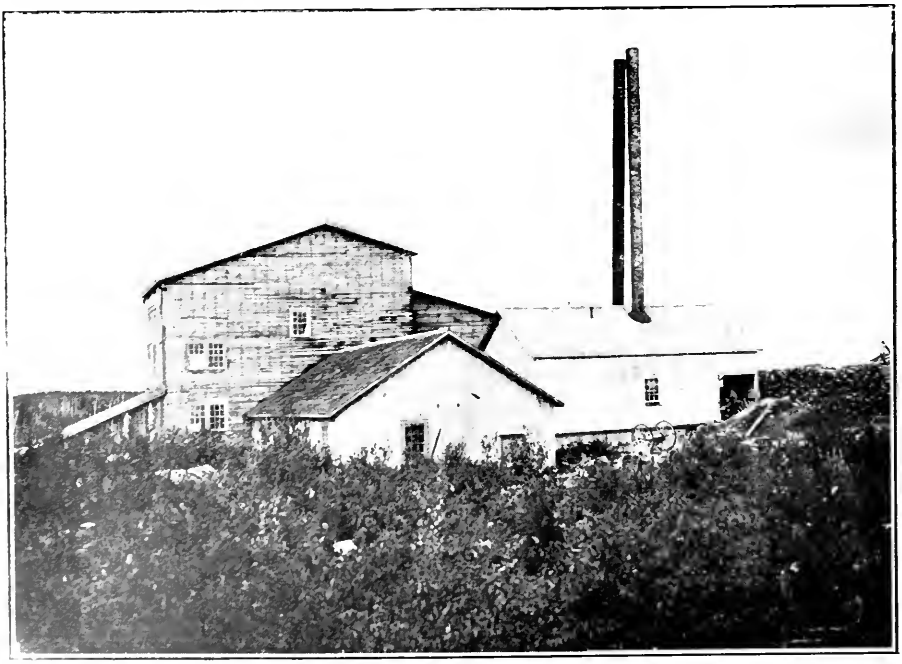
The power plant installed consists of two 60-h.p. locomotive firing boilers, the high pressure half of an air compressor developing about 400 cubic feet of free air per minute,

Open cut, St. Anthony gold mine, Sturgeon lake.



Shaft house, St. Anthony gold mine.

Camp buildings, St. Anthony gold mine.



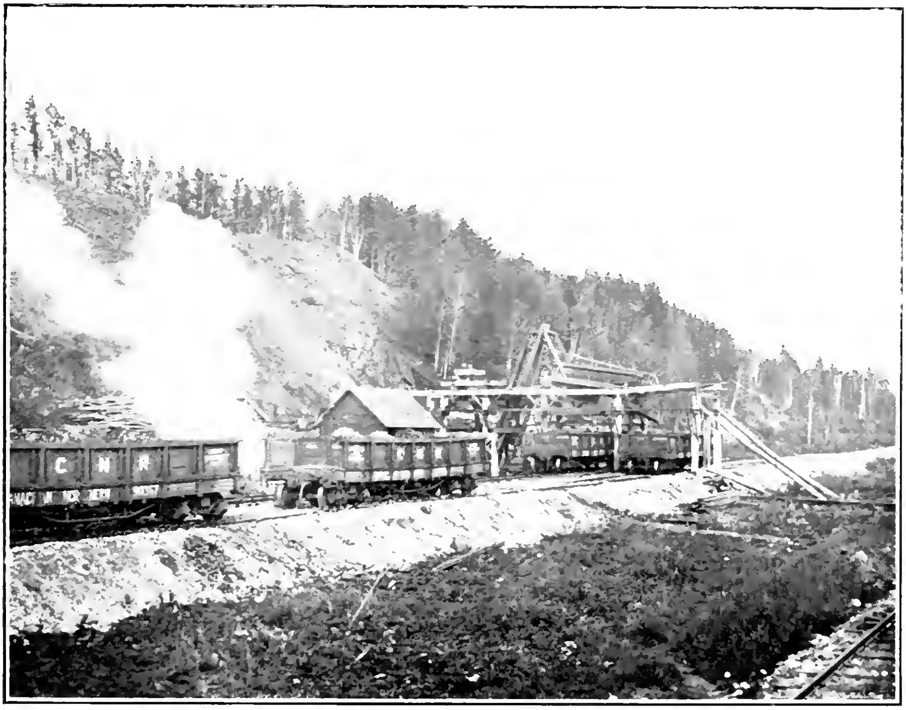
Power house and mill, St. Anthony gold mine.

and an $8\frac{1}{4} \times 10$-inch duplex cylinder hoist, 42-inch drum. A machine shop has been built east of the boiler house.

The vein occurs cutting the greenstone schist, the rock on the hanging wall side being very schistose in character, while on the foot wall it is more massive. The country being very heavily covered with bush, sand and gravel, with few outcrops, the work of prospecting is exceedingly difficult. A spur $3\frac{1}{2}$ miles in length will be built from the main line of the National Transcontinental railway to the mine. Until this railway is completed the ore will be stock piled. Capt. J. Webb is superintendent in charge, employing a force of 40 men.

Atikokan Iron Company

At the time of my inspection in September, 1907, the Atikokan Iron Company's blast furnace at Port Arthur was in operation. The ore used was from the company's mine at Atikokan, and on account of its high sulphur contents is first roasted in a



Atikokan iron mine.

Roberts roaster, to eliminate as much of the sulphur as possible. The furnace gases are used as fuel in roasting the ore and a 24-hour roast is given. The limestone used is from Kelly island, lake Erie. One hundred bee hive coke ovens have been built, and produce about 95 tons of coke per 24 hours, which is used in the company's furnace. A full description of the furnace is given in Mr. G. C. Mackenzie's report on "The Iron and Steel Industry of Ontario," in the present volume.

Mr. R. R. Jones is superintendent of the furnace.

Atikokan Iron Mine

As mentioned in the Sixteenth Report of the Bureau of Mines, the Atikokan mine began shipping May, 1907. From 100 to 150 tons of ore per day were shipped regularly until the mine closed in November, 1907. During this time ore was taken from the main vein cut in the prospect tunnel. From this tunnel drifts were driven east and west on the vein and stoping was begun. A raise was being put through to the surface on the vein on the west side of the tunnel. No work was done on the 8-foot vein north of the main vein. East of the tunnel mouth the rock has been blasted down as far back as the ore body, and ore was stoped from this by means of open cut work. The ore from the tunnel and open cut is trammed out on cars and dumped directly into a large gyratory crusher, which reduces it to 2-inch size. The ore is hoisted after crushing by a bucket elevator, when it passes over a trommel and the fines are separated, the oversize going directly on to the 50-ton ore cars on the spur.

The plant at the mine consists of three 100-h.p. return tubular boilers and the high pressure half of a Rand air compressor, "B-3" class.

Mr. F. Rodda is superintendent of the mine and employed a force of 60 men at the time of inspection.

West End Silver Mine

This property was not in operation at the time of my inspection in December, 1907, but was kept unwatered. From the owners it was learned that it had been worked during the greater part of the year. The work done consisted chiefly in driving the headings and stoping on the fourth level east side of the shaft. Several shipments of ore were made during the year, consisting of first grade ore from the mine and concentrates from the mill.

Beaver Silver Mine

The work of pumping out this mine began in June, 1907, after sixteen years' inactivity. During this time all the machinery at the mine and mill had been removed or destroyed by fire, so that on the re-opening new buildings had to be put up and new machinery installed. The company operating the mine is the Beaver Consolidated Silver Mines, Limited, with Wm. Snider, vice-president, Harry C. Gibbs, secretary-treasurer, and A. L. McEwen, manager.

In addition to unwatering the mine some mining work was being done on adit No. 2 at a point about 100 feet from the main shaft, where the floor of the adit was being stoped out to a depth of about 15 feet. In the main shaft the timber in the first 75 feet is in very bad condition, and will have to be renewed before operations in the shaft can be begun.

A small 30-h.p. locomotive firing boiler has been put in and a No. 6 Cameron sinking pump is used for pumping out the shaft.

Mr. A. C. Debernardi is mine captain, employing about 10 men.

II.—Sudbury and the North Shore

Canadian Copper Company

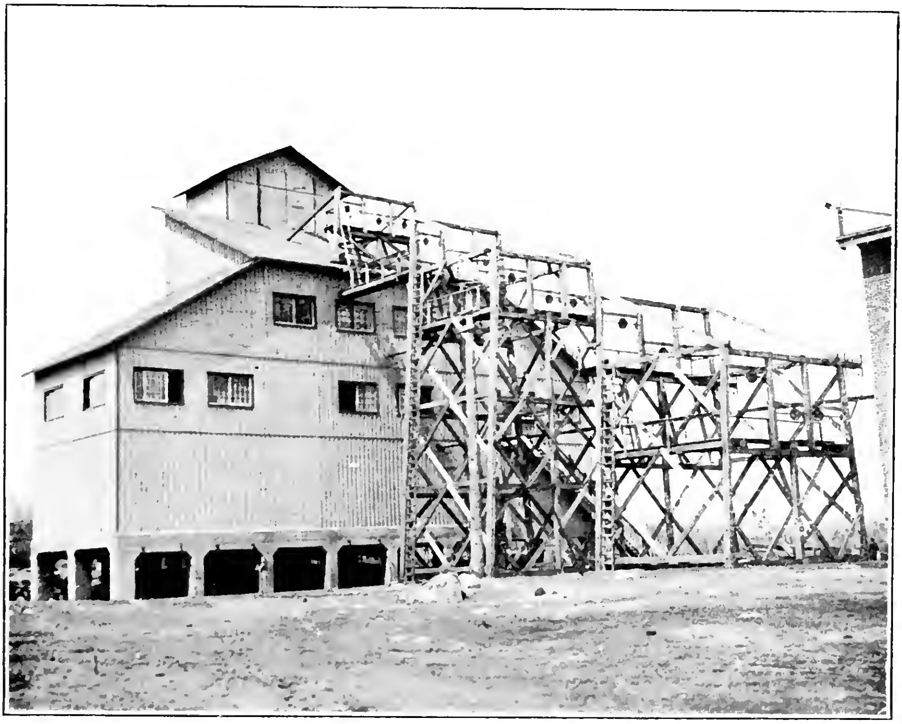
The Canadian Copper Company continues to operate its mines and smelting works for the production of nickel-copper matte, and was perhaps never in a better position to carry on its extensive business, as regards the condition and equipment of its properties, than it was last year.

Creighton Mine

In the Sixteenth Report of the Bureau of Mines a detailed description of the No. 2 rock house and power house at the Creighton mine was given. No change in the surface equipment has been made since that time, except the remodelling of the No. 1 shaft house.

No 1 shaft has been sunk to a total depth of 250 feet on an incline of 57 degrees, with levels at 75 feet, 150 feet and 210 feet respectively. The floor of the open pit is at the 150-foot level of the shaft. No. 1 shaft has been re-timbered throughout and a station cut at the third level. Sinking is also being continued below the third level.

No. 2 shaft, 330 feet west of No. 1 shaft, has been sunk to a depth of 340 feet, with levels at 190 feet and 275 feet respectively. On the second level at 190 feet a cross-cut has been driven north 90 feet. From this point a drift has been made north 110 feet and east 175 feet. A raise has also been put through to the surface. Stoping has been begun from this drift 50 feet from the cross-cut, and an area on the level 75 feet in length by 60 feet in width has been stoped out. On this level the open pit, to which access is had by both the cross-cuts from No. 1 and No. 2 shafts, has been stoped by the overhand method, to an area on the level of 175 feet in width by 275 feet in length.



No. 2 shaft house, Creighton nickel-copper mine.

On the third level of No. 2 shaft at a depth of 275 feet a cross-cut has been driven north a total distance of 164 feet. At 95 feet from the shaft drifts have been driven east 111 feet and west 94 feet. Sinking in the shaft is being continued below the third level.

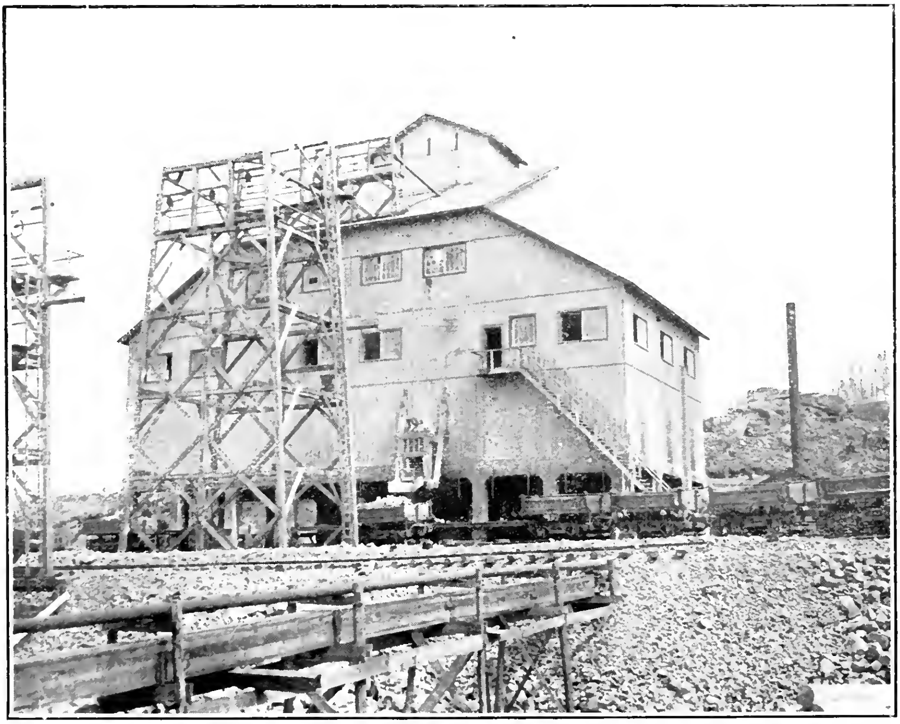
At the time of my inspection no ore was being hoisted from No. 1 shaft, owing to its being retimbered. About 500 tons a day were being hoisted from No. 2 shaft.

Mr. William Hambly is superintendent, employing a force of 150 men.

Crean Hill Mine

The Canadian Copper Company has, during the past year, been producing about 300 tons of ore per day from the Crean Hill mine. The shaft has been sunk on an incline of 57 degrees, to a depth of 400 feet, with levels at 60 feet, 120 feet, 180 feet, 275 feet and 375 feet. On the first level a cross-cut 65 feet in length has been driven to the ore body, which on this level is worked as an open pit. It is 60 feet in width

by 100 feet in length. From the shaft at the second level a cross-cut 90 feet in length has been driven to the ore body, which it cuts at its southern end. The ore has been stoped out on this level for 90 feet in width by 150 feet in length. At the centre of the deposit a pillar 40 feet by 25 feet has been left to support the roof. On the third level the cross-cut to the ore body is 90 feet in length. and the ore on this level has been stoped out for an area 60 feet in width by 150 feet in length. This third level floor has been stoped out, putting the third and fourth level stopes into one. The fourth level has a cross-cut from the shaft to the ore body 60 feet in length; and the stope is 75 feet in width by 125 feet in length; all the ore from the third and fourth level stopes being trammed from this level. A motor-driven station pump has been installed on this level. The fifth level, at 375 feet in depth, has a drift driven east 257 feet. A diamond drill station has been cut, and two diamond drills set to work to test the ore body at a greater depth.



Shaft House, Crean Hill nickel-copper mine.

At a depth of 200 feet in the shaft a dike was encountered cutting across the shaft at nearly right angles. The dike is 40 feet in thickness, and on each side of it there is from 6 to 12 inches of clayey material. The dike cuts through the ore body, but at the intersection it is mineralized and is stoped out as ore.

The rock house is similar to the No. 2 rock house at the Creighton mine, except that the ore is sorted on the crushing floor instead of being dumped directly into the crushers. On this floor all the rock is picked out. The mixed ore and rock is crushed, and the rock picked out on the sorting table.

The power house and plant is similar to that at the Creighton mine. A number of houses for the employees were built during 1907. Instructions were given regarding scaling and to have a railing placed around the open pit.

Mr. R. M. Meek is superintendent, employing a force of 400 men.

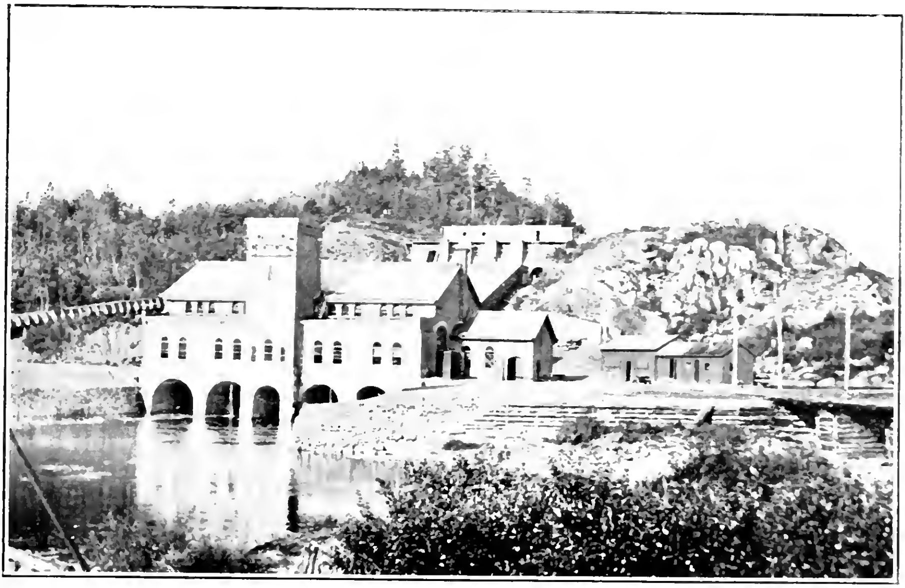
Quartz Mine

The quartz mine near Naughton is worked to provide sufficient quartz for the smelter requirements. At the time of my inspection the mine was not in operation, an adequate amount of quartz being on hand.

Cobalt Refining Plant

The plant of the Orford Copper Company for the treatment of Cobalt ores has been in operation continuously during the past year. The company treat here more particularly the higher grade ores from the Cobalt camp, although a small amount of the lower grade ores is also handled: altogether about 20 per cent. of the tonnage from the camp is treated here.

Some changes have been made in the treatment of the ores during the year, more particularly with regard to the speiss. A new furnace has been put in. The speiss, which originally was shipped direct from the blast furnace is now re-ground and



Canadian Copper Company's power house, High Falls, Spanish river.

roasted in the Edwards roaster,—which has been altered in form to be more applicable to the roasting of speiss,—and subjected to a leaching process. The silver bullion from the blast furnace is remelted in a small oil furnace and cast into bars of approximately 500 ounces in weight. Electric power has been installed at the plant, motors being used to drive all the machinery.

Mr. Mackenzie is superintendent of the plant.

Roast Yards

No. 3 roast yard, north of the town, has been greatly enlarged during the year. The ore from the Creighton mine is roasted, but that from the Crean Hill mine is smelted green. The Creighton ore is brought to the company's siding at the roast yards by the Manitoulin and North Shore railway. It is unloaded from the cars at the roast heaps by contract work, a certain price being paid for unloading the ore from the car and building the roast heaps. The roasted ore is loaded from the roast beds into

Ingoldsby drop bottom cars by a steam shovel and taken to the bins at the smelter from which the charging trains are loaded.

Three sintering furnaces have been put in operation on the site of the old west smelter, for the purpose of preparing the fines for use in the blast furnace. Old converter pots are used. A perforated bottom is placed in the pot and the fines mixed with a certain amount of coal, fired and a low blast turned on. The ore is roasted, and through the heat generated, the fine particles are cemented together, giving a product very adaptable for use in the smelter

Mr. E. W. C. Perry is superintendent of the roast yard and sintering plant.

Smelting Plant

A full description of the smelting plant was given in the Sixteenth Report of the Bureau of Mines. During the last year, however, it was enlarged by the installation of a converter blowing engine, rope-driven by an Allis Chalmers-Bullock induction motor of 1,250-h.p. capacity, working at 2,200 volts. To furnish this electric power an addition was made to the power plant at High Falls. The power house at High Falls was designed with space for four penstocks 9 feet in diameter, through which water enters to the turbines at a maximum speed of 7.2 feet per second. Two turbines designed for a maximum of 3,350 horsepower, each directly connected with a 2,000 kilowatt generator. were originally installed. During 1907 another turbine and generator were being installed which, when completed, will give a total power available of 7,500 h.p.

A converter building 280 feet long and 95 feet wide has been erected during the year with space for 10 converter stands, of which number 5 are at present installed. The four converter stands in the furnace building will be taken out to make room for two additional furnaces.

The relining department is a continuation of the converter department, and is 112 feet long and 60 feet wide, with a shed 35 feet in width on each side.

The following description[1] of the converting and relining plant is extracted from an article by the superintendent, Mr. David H. Browne:—

Back of this are the storage bins for quartz, clay and old linings with a floor space 60 feet by 60 feet, and behind this again the machinery for crushing and drying quartz and clay and elevating them to the storage bins. This occupies a floor space of 70 feet long by 60 feet wide. The total length of the building is therefore 522 feet.

Two Morgan electric cranes 55 feet 8 inches span with 50-ton main and 20-ton auxiliary hoist will be used to handle the shells in the lining and blowing rooms.

Furnace matte from the cupola building will be taken across on three tracks to the Bessemer department by means of motors. The matte pots will be lifted and poured by the electric cranes. Owing to the nature of the ground it is not possible to arrange the converter building on a lower level so that the matte can be poured direct from matte cars into the converters. These ten concrete stands are controlled by two pulpits, each handling five stands. The control is entirely electric. Each converter is operated by a 30-h.p. induction motor, with solenoid brake. This is directly connected to a bronze worm which, by two gearings, transmits the power to the drive trunnion of the converter.

The slag from the converters is to be poured into steel pots which are lifted by the crane and set on a slag car, on which it is taken out of the building and poured into a slag casting machine. The casting machine is a circular steel framework, 58 feet in diameter, resting on a circular track. On this framework rest cast iron moulds forming a continuous flat ring. Each mould is 12 inches by 30 inches by 4 inches, and holds about 150 pounds of slag. This ring is slowly rotated under the stream of slag poured down from the slag car. The slow rotation allows time for the slag to cool before the moulds reach a hand controlled tripper, which reverses the mould and drops the material into a hopper. Below this hopper a mine skip takes the slag, carries it up an incline track and drops it into a steel bin of 500 ton capacity above the charging tracks.

The converter matte will be handled in clay lined ladles by the cranes and poured into moulds under the shed roof. As soon as the lining of a shell is burned out the shell is lifted by the travelling crane and placed on one of the sculling cars which run on

[1] "The Mining and Smelting Equipment of the Canadian Copper Company."

standard gauge tracks from the main building out under the shed roof to the south side. The space between columns in the main buildings is filled with sheet steel doors of the roller blind type, which can be raised and lowered to allow the sculling cars to pass out. After the shells are sculled, the cars are pushed back, and the shells lifted by the travelling cranes and carried to the relining platform. Here they are dropped on cars at each side of a sixty-foot platform, twenty-five feet wide and ten feet high. This platform is in the centre of the relining department with space on each side for five relining cars. Down the centre of this relining platform run two narrow gauge tracks, which bring the mixture of quartz and clay from the Carlin mills.

The lining is done by ramming machines, which are handled by jib cranes, three on each side of the platform. The tops are to be lined by ramming around a mould instead of by hand, as at present.

As fast as the shells are lined, and the tops are replaced, the lining cars are pushed out under the shed roof, which lies at each side of the relining room. This brings the shells under a row of hoods and along side of a wood storage platform, from which the cordwood is handled for drying the lining.

When this has been completed, the cars are again pushed back to the lining platform, the shells lifted off and placed on the blowing stands by the travelling cranes, and the cars are ready to receive a fresh shell for lining. The motion of the drying cars back and forth from the lining platform is effected by ratchet gears on the cars.

The quartz and clay mixture for lining is made up in the crushing department, above which are the storage bins. These bins are of sheet steel and hang from the side and central columns in a catenary curve. There are six bins, one set of three on each side containing respectively crushed quartz, dry clay and old converter linings from the sculling shed. On each side below each bin-row are narrow gauge tracks on which run side-dump cars which gather the mixture of clay and quartz from the bins and dump it into the mills. These tracks are on platforms five feet above the relining platform level. The crushed mixture is taken from the mills by a plough attached to the side of each pan, which scrapes the mixture off the pan and delivers it into cars which run down the centre of the mill floor and out along the relining platform. In this way the usual wheel barrow work is avoided. Space is provided for six mills, three on a side, each mill being below the level of the tracks which bring the supply of quartz and clay, and above the level of the tracks which take away the crushed and mixed product to the lining platform.

At the rear of the bins and mills are the quartz crushers and clay driers. These occupy a floor space 60 by 70 feet. On either side of this end of the building are standard gauge tracks, on which quartz and clay are brought in. The clay is all passed through a Ruggles-Coles drier, which removes the moisture and rolls it into the shape of pellets. This is necessary in winter, in order to avoid freezing in the bins. During part of the summer drying is not required.

Mond Nickel Company

The Mond Nickel Company has now two shipping mines from which to draw its supply of ore. The Garson mine, in Garson township, began shipping on the completion of the spur from the Canadian Northern railway, Moose Mountain branch. The Victoria mine has been shipping steadily during the past year, but is somewhat handicapped at present owing to its inadequte power plant for handling the tonnage from its deeper workings. This is, however, expected to be remedied by the first of January, 1909, when its plant will be renewed, using electric power in place of steam.

The company is developing a water power in Lorne township, 9 miles southwest of Victoria Mines on the Vermilion river. At present about 1,200 kilowatts will be developed. Electrical machinery is being installed both at the smelter and at the Victoria mine. The management expects to have the new power stations at the smelter and mine ready for operation by the first of January, 1909.

Victoria Mine

The main shaft at the Victoria mine is now sunk to a total depth of 940 feet, being the deepest mine in operation in the Sudbury district. Work at the time of my inspection was being done on the sixth, seventh, eighth, ninth and tenth levels. The shaft has, during the last year, been sunk from the ninth to the tenth level, a distance of 150 feet. On the sixth level machines are at work, on the stope between the fifth and sixth levels on the east ore body. The ore is being trammed from this level. On

the east and west ore bodies, between the seventh and eighth levels, machines are at work stoping. The ore is trammed from the eighth level from the east ore body by means of a chute. On the ninth level a raise is being put through to the eighth on the west ore body. The work of cutting a station on the tenth level was in progress at the time of my inspection. No work is done on the upper levels during the winter time owing to the amount of ice that accumulates.

Mr. H. W. Hixon has resigned, and has been succeeded by Mr. C. V. Corless as manager. Mr. O. B. Hall has been made mine superintendent.

Garson Mine

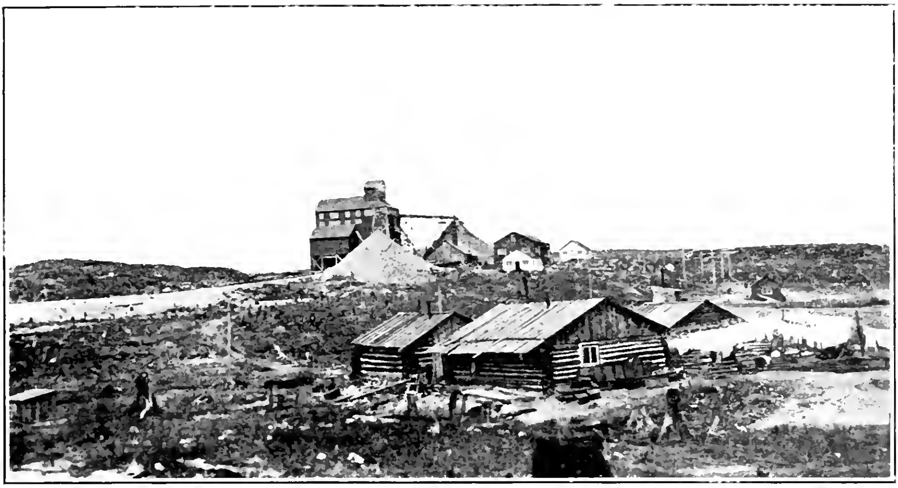
This property, owned by the Mond Nickel Company, has been added to the shipping list during the last year, 200 tons per day being at present shipped by way of the Canadian Northern railway to Sudbury, and thence by Canadian Pacific railway to Victoria Mines. The ore is at present smelted without roasting, but preparations have been made for taking the ore from the siding at the smelter to the roast yards by the aerial tram.

The underground developments at the Garson show the ore body on the first level at 100 feet in depth to be reached by the main cross-cut from the shaft to the drifts 80 feet in length. Drift 11 has been driven south 100 feet to number 11 ore body, which has been opened up by cutting a section with an area of 75 feet by 50 feet. A raise has been put through from this ore body to the surface. The main cross-cut has been driven 35 feet further to drift 12, which has been driven south to ore body number 12. The section of this ore body is 100 feet by 30 feet in area. Drift 13 to the north has been driven 75 feet towards number 13 ore body. Drift 14 has been driven north 240 feet to ore body number 14. This ore body has been opened up to an area of 75 feet by 40 feet, and a raise put through to the surface. No stoping has been done on this level as yet, except in cutting the section of each ore body. On the second level, at a depth of 200 feet, the cross-cut from the shaft to the drifts to the ore bodies has been driven 45 feet Drift 21 to the south has been driven to the south a distance of 130 feet, where the section of the ore body is being cut. Drift 22 has been driven north 100 feet to ore body 22, on which the section is being cut. From this ore body, drift 23 is being run to the northwest to cut the ore body. The third level, at a depth of 300 feet, has stations cut and drifting to the ore bodies has been commenced. The shaft was being sunk to the fourth level, a depth of 360 feet having been attained.

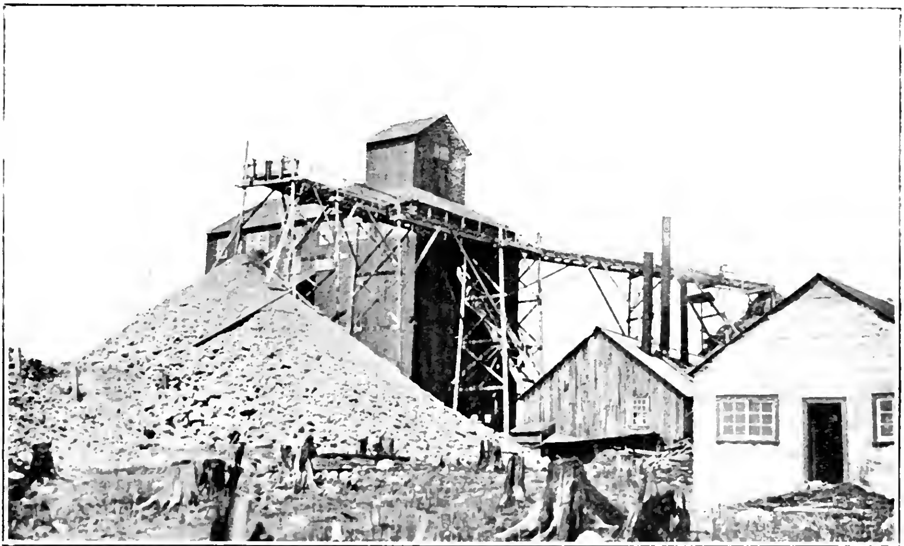
A shaft house has been erected having a height of 80 feet. The ore is hoisted in cars, holding approximately a ton of ore, on cages. It is then dumped over a grizzly on to a sorting floor, where the rock is picked out. On this floor are placed two jaw crushers, one for ore and the other for rocky ore. On the floor beneath are placed two bumping tables where the ore is again sorted. Beneath this floor are storage bins for ore and waste rock. The tracks of the Canadian Northern railway spur run beneath the rock house, and the ore is loaded from the ore bins direct into the ore cars. Four hundred horse power of electric energy is supplied by the Wahnapitae Power Company to the mine. An electric Lidgerwood pattern, double drum hoist, of 150-h.p. capacity and a compressor, belt-driven by electric motor of 150-h.p. capacity, developing power for 14 drills, have been installed. Electric pumps have been put in near the reservoir to supply water to the power house. The pumps underground are driven by air.

A large number of cottages have been built near the mine for the accommodation of the employees.

Mr. A. Sharp is resident superintendent. Instructions were given regarding cage and shaft openings.



Garson nickel-copper mine; shaft and power house.



Garson nickel-copper mine; nearer view of shaft house.

Cottages at Garson nickel-copper mine.

Worthington Mine

Work at this mine, which is situated immediately north of the track at Worthington station, C. P. R., was commenced again in September, 1907, after having been closed down since September, 1894.

The mine is mentioned in the First Report of the Bureau of Mines as having shaft No. 1 sunk to a depth of 35 feet, and shaft No. 2 to a depth of 95 feet. Very little mining work had been done in the mine since reopening. No. 1 shaft is 200 feet in depth with levels at 100 feet and 200 feet respectively. Both the first and second levels have been connected with No. 2 shaft by means of a short drift from the shaft to an open stope. This is on the east side of the shaft. A stope about 80 feet in length by 75 feet in height has been opened up, west of the shaft on the first level. On the second level west of the shaft, a drift has been run in about 35 feet where a section 25 feet by 25 feet has been cut, but no stoping done. Some mining work is being done on this level.

The old machinery, consisting of two boilers, straight line air compressor and hoist have been overhauled and put in working condition. Three cars of ore have been shipped to the Mond Nickel Company's smelter at Victoria Mines.

The mine was formerly owned by the Dominion Mineral Company. It is now being operated by the Mineral Development Company, with Jas. W Pyke, president, and F. C. Hirsch, manager.

The Whistle Property

This property is on lot 6 in the fourth and fifth concessions of the township of Norman. During the winter considerable diamond drill work was done, for the purpose of defining the ore body. With the completion of this drilling, work has been begun sinking a shaft. The property is about four miles from the Moose Mountain branch of the Canadian Northern railway, to which a spur will be put in as soon as the mine gets on a shipping basis.

Ontario Nickel Company

During 1907 considerable work was done by this company chiefly in building a refining plant about half a mile west of Worthington station. Some work was also done at the Totten mine. All work, both at the mine and refining works was stopped in the fall of last year.

Gold Mines

A number of gold mines and prospects, situated principally on the east shore of lake Superior, were under development for part of 1907. Mention is made of these as follows:

Shakespeare Gold Mine

The Shakespeare gold mine ceased operations temporarily in the fall of 1907, and had not, at the time of my inspection, been reopened. The development work described in the Sixteenth Report of the Bureau of Mines has been continued, but, on account of the mine being closed down, the extent of the same could not be ascertained.

Grace Gold Mine

The Grace gold mine, five miles east of Michipicoten River P. O., has been purchased from the Algoma Commercial Company, of Sault Ste Marie, by the LePage Gold Mining Company, Limited, of which Mr. Angus Gibson is manager. The mine was reopened in the fall of 1907, after having been closed for four years. Mining operations had, however, not begun at the time of my inspection in October, 1907. The development work at the mine, as described in the Twelfth Report of the Bureau of Mines, remains, therefore, the same.

On the development of electrical power on the Michipicoten river by the Algoma Power Company, the LePage Company contracted for 200 horse power, and commenced the work of installing electrically driven machinery at the mine, consisting of an air compressor, developing 545 cubic feet of free air per minute, belt driven by motor, 50-h.p. motor-driven hoist and 50-h.p. motor for driving mill machinery. The scarcity of fuel has always been a handicap to the successful operation of the mines in this section. With the development of electrical power this handicap is removed.

Golden Reed Mining Company

A number of prospects are being developed in the vicinity of the Grace mine. About three and a half miles distant from the Grace the Golden Reed Mining Company have sunk a shaft on a quartz vein to a depth of about 50 feet. The machinery for a 3-stamp Merrall mill has been purchased and was being forwarded to the property. Machinery for the use of electrical power is to be installed.

Braddock Development Company

In the vicinity of the Golden Reed property the Braddock Development Company have taken up mining claims numbers 380, 1568, 1239 and 379. A shaft has been sunk on one of these to a depth of 55 feet.

Copper Mines

With the decline in the price of copper in the fall of 1907, and the financial stringency in the United States and Canada, nearly all the copper prospects along the north shore of lake Huron were closed down. It is hoped, however, that during the next year considerable work will be done in opening up a number of them.

Hermina Mine

At this property work has been carried on continuously all winter. The shaft remains the same depth as at last inspection. No work has been done on the first level. On the second level at a depth of 220 feet drifts have been driven west 395 feet and east 260 feet. At 110 feet from the shaft a cross-cut 30 feet in length has been driven. On the third level at a depth of 320 feet a cross-cut has been driven east 60 feet and south 120 feet. From this drift, a drift and cross-cut have been driven north of east 80 feet. On the fourth level a cross-cut has been driven north 90 feet. From a point 60 feet from the shaft in the cross-cut, a drift has been driven east 100 feet, and from a point 70 feet from the shaft, a drift has been driven southeast 45 feet. A drift has been put in west from the main cross-cut a distance of 200 feet. The surface equipment remains the same as at last inspection.

A spur line from the Canadian Pacific railway is being built to the mine, a distance of four and a half miles. Part of the grading has already been done, and the work on the line is expected to be completed this year.

Mr. S. H. Bryant is superintendent of the mine, employing a force of 25 men.

The Algoma Custom Smelting and Refining Company, in which the officers of the Hermina Mining Company are chiefly interested, has erected a copper smelter at Thessalon. The smelter is situated one and a half miles from the railway on the lake shore. Docks have already been built, and it is expected that a spur from the railway to the smelter will be constructed this summer. The smelter is a custom plant, and contracts with some of the mines, particularly the Superior mine, to furnish ore, are under consideration.

Superior Mine

The Superior Copper Company has not been operating its mine since November, 1907. Up to that time development work on No. 6 shaft shows the following work done: The shaft has a depth of 400 feet with levels every 100 feet. On the first level 490 feet

of drifting has been done on the vein, which has a strike of northwest by southeast. A raise has been put through to the surface from the northwest drift. On the second level 240 feet of drifting has been done northwest and southeast of the shaft. On the third level there are 120 feet of drifting, and stoping has commenced. A raise has been put through to the second level. On the fourth level about 25 feet of drifting has been done.

The power plant consists of two 100-h.p. boilers, one 12-drill air compressor, one 150-h.p. engine and large single drum hoisting engine.

The grading on the spur line from the mine to the Algoma Central railway is nearly completed, when it is expected that the mine will begin shipping.

Mr. F. C. Smith is general manager of the company.

Campbell Copper Mine

During the last year Dr. D. Campbell has been developing a copper property consisting of 40 acres of the north half of lot 6 in the eighth concession of Plummer Additional, about one-half mile from the Sault branch of the Canadian Pacific railway, four miles from Bruce Mines and four miles from Desbarats. The vein, which has a strike of east and west, has been stripped for 125 feet, and consists of quartz carrying chalcopyrite along with several other ores of copper such as bornite, azurite and chalcocite. A shaft has been sunk south of the vein about 30 feet, to a depth of 50 feet, and a cross-cut driven north about 20 feet. A small upright boiler, hoist and drill have been used in the development work. The vein is in slate conglomerate about 30 feet from a diabase contact. The diabase occurs in the form of a dike with a width of about 125 feet cutting across the location in an east and west direction parallel to the vein. The pebbles in the conglomerate are mostly granite.

Reilly Prospect

On the south half of lot 7 and the west half of the south half of lot 8, in the third concession of the township of Johnson, comprising mining claims 745, 746, 747, 748, 743 and 744, Mr. J. F. Reilly is prospecting for copper. A large number of test pits have been sunk, the deepest being 25 feet. The ore where found consists of a chalcopyrite with occasionally a little bornite and malachite.

Iron Mines

Two of the most important iron ore deposits in Ontario are situated in this region, one being tributary to lake Huron, and the other to lake Superior. These are Moose Mountain and the Helen mine.

Moose Mountain

The Moose Mountain iron mine was not in operation at the time of my inspection, but the following notes on the development work, equipment and transportation facilities were obtained from the manager, Mr. N. L. Leach:

Development work at the properties of the Moose Mountain, Limited, has proven the existence of several large deposits of merchantable ore, principally magnetite, and a small amount of hematite. The ores occur in the following rocks of the Keewatin age. Those in close proximity to the ore bodies consist principally of diorite, diabase, hornblende-schist and hornblende-gneiss, all of which may be collectively referred to as greenstone. In a few instances granite comes in contact with the ores. Numerous exposures of magnetic ores are to be found. Where weathered the ore presents gray, dark green and black appearances, and glaciated surfaces have the lustre of metallic iron. When crushed for shipment the ores have a steel gray appearance. These ores can be delivered to any blast furnace in Canada or the United States, tributary to the great lakes, and the product from the Moose Mountain mines will be disposed of in the above markets.

The present guaranteed analysis on ore sales is:

Iron	55.50
Phosphorus	.10
Silica	13.29
Manganese	.02
Alumina	1.21
Lime	3.60
Magnesia	3.15
Sulphur	.011
Titanium	None
Moisture	1.00

So far actual mining operations have been confined to the No. 1 or original Moose Mountain deposit. The surface of the ore body at this point is approximately 140 feet above the level of the railroad loading tracks. The ore is won by underhand stoping from an open face of 60 to 70 feet in height, and is trammed out to a large chute discharging thirty feet below the level of the bottom of the present stope into a No. 8 Austin gyratory crusher, which reduces it to a maximum size of five to six inches diameter. Leaving the No. 8 crusher the ore passes through a revolving screen 48 inches × 12 feet in size, with quarter-inch perforations, the rejections going direct to the foot of the elevator pit, and the balance to a No. 5 Austin gyratory crusher discharging into the 14 × 30-inch buckets of a 52-foot centre belt elevator, which elevates the ore into the loading bins, whence it discharges through hoppers into the railroad cars.

A 16 × 42-inch Jenckes Corliss engine, to drive the crushing plant, and two 150-h.p. return tubular boilers, constitute the present power plant, the machine drills having been operated by steam up to the present time.

Messrs. Mackenzie and Mann, appreciating the possibilities of the ore tonnage as a source of revenue for their railroads, became interested in the property, and as a result a branch of their Canadian Northern Ontario railway from Toronto to Sudbury, has been built from Sudbury north to the mines, a distance of 35 miles. A six-mile spur from the main line, a few miles south of the French river, has been constructed to the Georgian bay at a point known as Key Inlet, and is the final link connecting the mines with the great lakes, making a rail haul for the ore of about eighty miles, or about the same as the average haul of the three iron ore carrying roads of Minnesota

Ore docks for the transhipment of the ore are now under construction by the Mackenzie and Mann interests at the Key. A splendid natural harbor has been secured there with 24 feet of water alongside the ore docks, more than enough to float the largest vessels on the great lakes, and the Key as a shipping point by water is 500 miles nearer any of the iron ore receiving ports as compared with ports at the head of lake Superior. This will be a considerable factor in the securing of favorable lake freight rates.

The docks are of unique construction, and will be unlike any on the great lakes for the handling of iron ore. The ore from the mines, loaded in hopper-bottomed cars, is dumped from a trestle to a stock-pile ground beneath. Under this stock-pile ground, in line with the centre line of the trestle, is a tunnel through which a forty-two inch belt will convey the ore to a similar belt at the water's edge, which in turn conveys and elevates the ore to the dock trestle, sixty feet above the water level. It is then tripped off the belt, weighed by an automatic device, and dumped into pockets from which it will be spouted into the hold of the vessels alongside the dock. It is expected that these belts will have a capacity of 800 tons of ore per hour.

The Helen Mine

The Helen iron mine at Michipicoten was inspected in October, 1907. At that time the development work done since my former inspection consisted of No. 1 shaft being sunk to the fourth level, a distance of 60 feet below the third level, or a total depth of 346 feet. A drift has been driven from No. 1 shaft to No. 2 shaft, a distance of 100 feet, and a raise put up 30 feet for No. 2 shaft connection. A drift has been made 100 feet from No. 2 shaft to the ore body.

During the year all the ore shipped was stoped from the third level. The workings on the third level were described in the Sixteenth Report of the Bureau of Mines, and no new development work on this level has been since done, the work consisting of only working out the stopes that were blocked out.

A considerable tonnage of iron pyrites was shipped in 1907, taken from pockets of granular pyrites that occur in the northwesterly part of the mine, essentially in the form of chimneys in the iron ore.

During the season of navigation about 1,000 tons of iron ore per day were raised.

The mine is now equipped at the several levels with a mine telephone, which is connected on the surface with the shops, office and superintendent's house.

The attention of the superintendent was called to the need of very careful scaling of the stopes, particularly when they have reached the point at which they are nearly worked out, and openings are being cut between the main stopes; also to the necessity of seeing that the storage boxes for the day's supply of dynamite for the contractor are kept in drifts that are not being used for tramming, and that only a few boxes should be placed in the same drift.

Mr. C. B. Keenan is superintendent, employing a force of 150 men.

III.—Temiskaming

Northland Pyrites Mine

This property was described in the Sixteenth Report of the Bureau of Mines, as the James Lake pyrites mine. It was in continuous operation during the past year. The underground development shows the shaft to have been sunk to a depth of 170 feet with the first level at 100 feet. On this level drifts have been driven north 110 feet and south 260 feet. North of the shaft stoping has been begun, a stope 80 feet in length by 25 feet in height having been made. South of the shaft stoping has also been commenced, the ore being stoped out for an area of 80 feet in length by 20 feet in height. North of the shaft 240 feet the ore has been taken out by open cut workings for a depth of 45 feet by a length of 75 feet. This stope has been connected with the first level by a raise and stoping from the level begun. The ore is hoisted to the shaft house where it is broken and the rock cobbed out. It is then dumped direct from the storage bin to the cars, a siding from the Temiskaming and Northern Ontario railway having been built to pass under the ore bin.

The equipment consists of two 100-h.p. boilers and a 12-drill air compressor and hoist.

Mr. Ronald Harris is manager, employing a force of 35 men.

Temagami Mining and Milling Company

Work was carried on at this property during the year until April, 1908, when all operations ceased. During the period of activity an adit was driven into the hill on the vein and two shafts sunk to depths of about 50 feet.

Mr. R. Peverly was in charge of operations.

Silver Mines

A description of the working mines of the Cobalt camp will be found in chapter II of Part II of the Sixteenth Report of the Bureau of Mines.

In chapter III of the same Report Mr. C. W. Knight briefly describes the more important silver-bearing veins of the Montreal River area. No inspection was made of this area in 1907, as little active mining work had been done.

Two plants for the treatment of Cobalt ores have been recently erected in Ontario; one at Thorold and the other at Deloro, and are in active operation. A description of these plants is also given in Part II of the Sixteenth Report.

IV.—Eastern Ontario

Gold Mines

The gold mines of Eastern Ontario have had a varied and uncertain experience. During 1907 and the first part of the present year there have been in operation at different times six mines, namely, the Pearce, Sophia, Golden Fleece, Star of the East, Big Dipper and Boerth. All of these are properties on which work was formerly done,

and which have been closed down chiefly through lack of funds to carry on exploration. New companies have been induced to take over the properties, or a re-organization of the old company has taken place to provide further working capital which in most cases has proven insufficient. The mines in Eastern Ontario have this year been benefited by the falling off in the demand for labor, the laboring class being compelled to seek employment here where the wages are less than in the northern parts of the Province.

Star of the East

This mine was in operation at the time of my inspection in June, 1907, but ceased work during the year. During the time of its activity a test was made of the ore as to its value and milling properties under the direction of the superintendent Mr. Brooks

Golden Fleece

The Golden Fleece, situated on lot 25 in the sixth concession of the township of Kaladar, was in operation during 1907. The shaft was sunk to a depth of 85 feet vertically and about 50 feet of cross-cut driven. No development was done in drifting on the vein on the 85-foot level. During the year a 10-stamp mill was erected and a two weeks' mill run made. The ore milled was taken from surface workings.

Pearce Mine

The Pearce mine is located on lot 8 in the ninth concession of Marmora township, adjoining the Deloro Mining and Reduction Company's works. The mine is owned by the Cleveland Gold Mining Company, and is leased by them to Mr. H. E. Lawson, who is at present operating it. The shaft has been sunk on the vein on an incline of 26 degrees, to a depth of 173 feet, the first level being at 60 feet and the second level at 140 feet. All work is at present confined to the second level south drift, which has been driven 125 feet. The stope from this drift has been carried up on the vein to a height of about 45 feet with a length of 40 feet, at a distance of 75 feet from the shaft. A drift has been driven north from the level 105 feet. Drilling is done by means of steam, a fan being used for ventilation. A 20-h.p. boiler supplies power for hoisting, drilling and pumping. The lessee is personally looking after the work at the mine. This property has been closed down for some time and was re-opened by Mr. Lawson in October, 1907.

Boerth Mine

The Boerth mine has been closed down for some years, but work was begun again in the spring of 1908. The old shaft has not as yet been unwatered, work being confined chiefly to the prospecting of the veins on or near the surface. A shipment was made from the mine in May, 1908, for experimental purposes.

Big Dipper

The Big Dipper Mining and Milling Company which controls the mining rights on lots 4 to 21 in the tenth concession of the township of Barrie, Frontenac county, have again begun operations. The work is being done chiefly on lot 4 in the tenth concession, under the management of Mr. J. Jamieson.

Sophia Mine

The Sophia mine, consisting of the west half of the east half of lot 14 in the tenth concession of the township of Madoc, and the west half of the east half of lot 15 in the same concession, has been taken over by the Madoc Mines Company from the original owners. The president of the new company is Geo. F. Adams of Auburn, N.Y., with W. C. Jirdinston, as manager.

The mine is described in the Tenth Report of the Bureau of Mines, page 117. At the time of my inspection, June 27th, 1908, the No. 3 shaft was being unwatered. No other work has been done on the property with the exception of putting the mill in shape for operation.

Eldorado Copper Mine

No work has been done at this mine since last inspection, and the description of the mine in the Sixteenth Report of the Bureau of Mines gives the extent of the working up to the present. A change in the management took place last year, and it was the intention of the new management to begin work at once. The drop in the price of copper, together with the general inactivity, has caused the mine to lie idle up to the present.

Lead Mines

The revival of lead mining in Eastern Ontario caused to some extent by the high price of lead, suffered a severe set back in 1907. The Stanley Smelting Company, who were operating three lead mines and one small lead stack, got into financial difficulties and were consequently compelled to cease operations. As a result at the present time all the lead properties in Ontario are lying idle.

Richardson or Olden Zinc Mine

This mine was closed down during the winter of 1907, but work was resumed at the mine on a small scale during the spring of 1908. Work has been confined chiefly to Nos. 1 and 2 shafts. The higher grade ore extracted is hand-jigged, and the lower grade ore put on the dump for future treatment. Mr. J. Sullivan is forman in charge.

Iron Pyrites

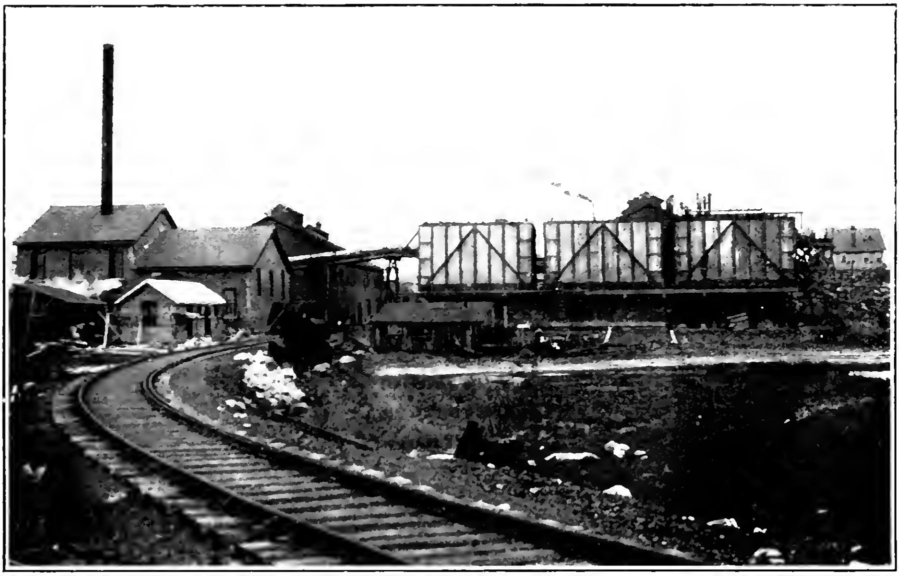
The Hungerford mine was the only pyrites mine in operation in eastern Ontario at the time of my inspection in June, 1908. There are, however, a number of prospects having fairly good possibilities which have shipped some ore.

Hungerford Mine

The Hungerford mine, owned by the Nicholls Chemical Company, is situated on lot 23 in the twelfth concession of the township of Hungerford, and within an eighth of a mile of the Canadian Pacific railway station known as Sulphide. The shaft is the same depth as at last inspection. On the 100-foot level north vein the drifts on the vein have been extended to 240 feet east and 250 feet west of the cross-cut.

No additional work has been done on the other vein on this level. On the 200-foot level drifts have been driven on the north vein from the cross-cut 240 feet east and 250 feet west. A raise has been put through from the level near where the cross-cut strikes the vein, to the first level. Chutes have been made at intervals of 50 feet along the vein for 300 feet. In place of the ore being stoped out between the chutes along the vein and timber put in, the ore has been left as pillars and the chutes have been connected overhead. The ore has been broken down in the stope for 300 feet in length and to within an average of 35 feet from the first level. Only sufficient ore has, however, been drawn from the stope to provide working room. Development work produces almost enough ore to keep the furnaces running. On the third level a drift has been driven east on the south vein a distance of 225 feet. On the north vein drifts have been driven east 360 feet and west 240 feet from the cross-cut. A raise has been put through from the third to the second level, and a winze has been begun on the north vein 50 feet from the cross-cut.

The acid works are located about 800 feet south of the mine, and treat about 750 tons of ore per month. They have been in operation since July, 1907, and were



Acid Works, Nichols Chemical Company, Sulphide.

Acid Works, Nichols Chemical Company, Sulphide—another view.

described in the Bureau's last Report. The power plant in the acid works consists of two 125-h.p. return tubular boilers with Cochrane feed water heater. A large underwriter fire pump and electric light plant are installed in the power house. An electric pump is to be installed at Black creek near the mine for pumping water to the artificial reservoir between the mine and works. The power plant at the mine consists of two 100-h.p. boilers and two compressors, having a capacity of 400 and 500 cubic feet of free air per minute respectively.

Mr. F. W. Lovejoy is superintendent of the mine and works, employing a force of 65 men.

Canada Mine

The Canadian Pyrites Company during part of 1907 was working this mine, which is on lot 26 in the twelfth concession of Hungerford, adjoining the Hungerford mine. It is at present closed down, but during the last winter some shipments of pyrites were made to the Nichells Chemical Company at Sulphide. A diamond drill was also at work part of the year testing the vein.

Mr. W. A. Hungerford is superintendent.

Iron Mines

The production of iron ore from Eastern Ontario at the present time amounts to about 8,000 tons per month, with prospects of soon being largely increased. It comes from the Wilbur and Mayo mines and is all magnetite, no hematite being at present produced. All the ore from these mines is shipped to Canadian furnaces at the Sault, Midland and Radnor, Que.

Wilbur Mine

The Wilbur iron mine, situated two miles south of Lavant station, on a spur line of the Kingston and Pembroke railway, has been taken over from the original owner, Mr. Wm. Caldwell of Toronto, by the Wilbur Iron Ore Company, and has been operated by them since October, 1907. During the winter the stock pile at the mine was shipped to the Sault and a new shaft house and ore bins built. All the work in the mine is carried on from the new shaft, which is south of the old working and is sunk on the ore body at an angle of 27 degrees following the dip of the ore. The shaft is 226 feet deep, and has levels driven every 50 feet. Most of the work at present is being done on the 50-foot and 100-foot level. On the 50-foot level drifts have been driven north and south from the shaft, 90 feet and 75 feet respectively, and the ore is being stoped out from above these drifts. On account of the flat dip of the ore body, the levels have to be carried very close together, and a great deal of the ore must be handled a couple of times before it can be loaded in the cars on the level. Pillars are being left at intervals of 25 to 30 feet to support the hanging wall.

On the second level drifts have also been driven north and south, and stoping is at present being carried on above the north drift. Other drifts have been run by the former owners at other parts of the shaft, but no work is at present being done in any of them. The ore is hoisted by means of a ton skip, and is dumped directly into the skips from cars on each of the levels. Thawing the dynamite is done in one of the old drifts, some distance from any of the present workings.

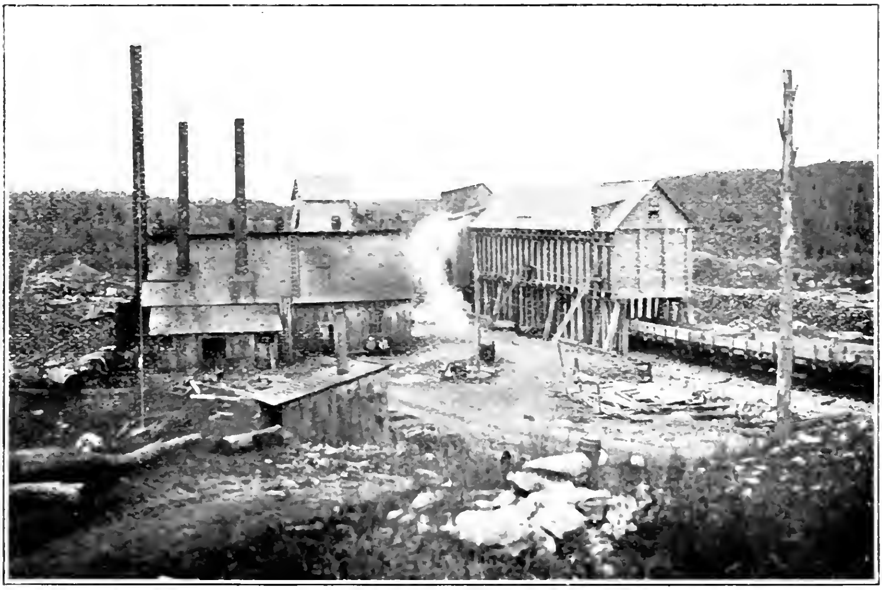
The ore dumps from the skip directly into a jaw crusher, and is hoisted by bucket elevator to a 50-foot picking belt, where a number of boys pick out the rock. The belt also acts as a conveyer to the several ore bins. These are built over the railway track and the ore is dumped directly from the bins on to the cars. The hoisting engine is placed in the rock house beneath the crusher. An additional plant has been installed consisting of a 125-h.p. return tubular boiler and a straight line compressor, placed in the old power house north of the shaft house.

Mr. Dunbar is president of the company, and Mr. A. Hesselbring, superintendent, employing a force of 65 men.

The upper part of the old workings of the mine is in a very unsafe condition, but no work is being done near it. The ore is magnetite, and has a strike on its outcrop of north and south, with granite as the hanging and crystalline limestone the foot wall. All the output is shipped to the blast furnace at Sault Ste. Marie, Ontario.

Radnor Mine

The Radnor mine, four miles from Caldwell station on the Canada Atlantic railway, and owned by the Canada Iron Furnace Company, was in operation during the greater part of 1907. Work at the mine was suspended in the fall of that year. The work done consisted chiefly in open cutting the deposit on the northwesterly side of the hill Mr. L. L. Bolton was superintendent in charge.

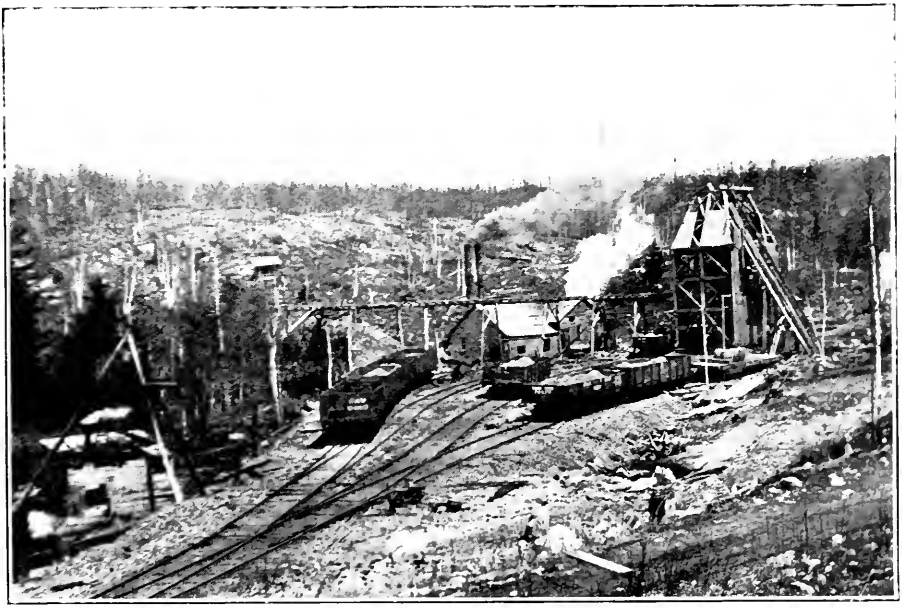


Wilbur iron mine.

Mayo Mine

This property has been described in former reports of the Bureau of Mines as the Mineral Range mines. The Mineral Range Iron Mining Company have leased their holdings to the Canada Iron Furnace Company, and the mines are at present being operated by the latter. The ore is hauled by the Barry's Bay and Bessemer railway from the mines to their siding on the Central Ontario Railway, one-half mile south of L'Amable station. The Canada Iron Furnace Company began operating the mines in February, 1908, with Mr. J. G. Harris as superintendent. Three diamond drill holes have been put down to test No. 4 deposit, one hole being put down to a depth of 350 feet.

At No. 4 mine a three-compartment shaft has been sunk to a depth of 75 feet on the ore body at an angle of 67 degrees. A station has been cut at the 50-foot level and drifts run west on the ore body 25 feet and east 20 feet. One skip track has been put down to this level, the other track being only to the level of the open cut at present. From the 50-foot level the shaft will be sunk vertically, the ore body having been proved



Mayo iron mine No. 4.

Mayo iron mine No. 4, open pit.

to have less of a dip at depth than is shown in the first 50 feet. The open cut described in the Sixteenth Report of the Bureau of Mines has been continued from the shaft for a distance of 250 feet, where the ore is mixed with considerable rock. The face of the open cut here is 50 feet in width and 30 feet in height. A winze is being sunk in the floor of the open cut 100 feet from the shaft. This will connect with a raise from the west drift on the 50-foot level. The hanging wall of the ore body consists of a hornblende schist three feet in thickness, followed by crystalline limestone. On the foot wall is found a few feet of hornblende schist, then some lean ore, followed by a small thickness of hornblende schist lying on the granite.

The skip track has been renewed and new 2-ton skips put in use. The waste rock is hoisted by skip and dumped on cars in the shaft house below the crusher. The ore is dumped directly from the skips into a Gates gyratory crusher. The company purpose erecting ore bins and using picking belts. The machinery at present installed consists of two 80-h.p. locomotive firing boilers, a double drum hoist with cylinders $12\frac{1}{4} \times 15$-inch, and a straight line air compressor. Two 125-h.p. return tubular boilers and new compressor are under order.

At No. 3 ore body a shaft has been sunk 25 feet deep at a point between two lenses of ore. The shaft will be sunk to greater depth and the ore bodies connected with the shaft and all hoisting from both ore bodies done from the one shaft. The west body has been opened up to an area of 35 feet wide by 40 feet in length, and about 25 feet in depth. The east body about 65 feet east of the west body, is opened up for 40 feet in length by 20 feet in width. A head frame has been erected at this shaft, and the ore is hoisted by skip and dumped directly on to railway cars on the siding. The single drum hoist formerly in use at No. 4 mine is now in use at this shaft. A small boiler furnishes steam for the hoist and for pumping. A 4-inch pipe line from the compressor at No. 4 mine has been laid to No. 3, to furnish the drills with power. This pipe line is 2,000 feet in length.

No work has been done by the present operating company on any of the deposits of the Mineral Range Iron Mining Company except Nos. 3 and 4.

Corundum

The corundum industry in Hastings and Renfrew Counties received a severe set back about the first of the present year by the closing down of the Canada Corundum Company, the largest corundum producer in Ontario. During 1907 the Company produced a considerable tonnage of marketable corundum.

The same system of open cut workings for mining the corundum bearing rock was continued as in former years, and a much larger tonnage was put through the mill each month. Mr. H. E. T. Haultain was general manager of the company up to the time of the mines closing down. During this year the company have been selling the corundum which they had in stock.

The Ashland Emery and Corundum Company operating in Carlow have been doing some prospecting during the year and also making some mill runs. A few shipments of corundum have been made, but operations have been carried on on a small scale. Mr. W. Mackie is in charge.

Feldspar

Frontenac county in 1907 as in former years produced all the feldspar that was shipped from Ontario.

Richardson Mine

The Richardson Mine in Bedford township produced the greater part of the feldspar that was mined in Ontario last year. All of the feldspar produced is shipped to the United States.

Pits Nos. 1 and 2 at the Richardson mine were worked in 1907 as formerly described. The pit now has a depth from its highest point of 90 feet. The sump at the centre of the two pits has been deepened and stopes are carried back from this sump to the limit of the productive zone. The quartz which occurs between the Nos. 1 and 2 pit and overhanging the feldspar of No. 2 pit has been mined to ensure greater safety for the workings, and shipped to the smelting works at Welland to be used in the manufacture of ferro-silicon.

Mr. M. J. Flynn is superintendent of the mine, employing during the summer 40 men.

Border Mine

The Border mine in the township of Portland, two miles east of Verona, was in operation a part of 1907. Work at the mine has, however, not been resumed this year.

Graphite

The graphite industry in Eastern Ontario received a stimulus during the first part of 1908 with the re-opening of the mine and mill at Port Elmsley and at the Black Donald graphite mine near Calabogie. New processes for the separation and refining the graphite are to be used, and good progress may be looked for.

Black Donald Mine

The Black Donald graphite mine, which has been held on sub-lease from the Ontario Graphite Company, has been transferred from the lessees to the Black Donald Graphite Company. The mine had not been unwatered at the time of my inspection, but the mill was being renovated and machinery installed similar to that in use in large graphite mills in the Eastern States. It is the intention of the management of the new company to begin mining operations as soon as the mill is ready to handle the output.

McConnell Mine

The Globe Refining Company has begun active development at the McConnell graphite mine in North Elmsley township at Oliver's Ferry, about 7 miles from Perth. No underground work had as yet been done at the time of my inspection, May 23rd, 1908, but there had been considerable surface trenching, and three diamond drill holes had been put down to test the extent of the deposits. A shaft house was being erected, and an inclined skip track was being built into the mine at an angle of about 45 degrees, this being the dip of the veins so far as yet determined. The skip will dump into a storage pocket in the shaft house, and the ore will be loaded from this pocket on wagons of about 4 tons capacity and hauled to the mill at Port Elmsley, two miles distant.

The workings up to the present consist of an open cut about 100 feet long and 25 feet deep. The graphite occurs in the form of flake graphite in limestone, the mineralized zone occurring in the crystalline limestone and having an easterly and westerly strike.

The concentrating and refining mill is situated at Port Elmsley on the river Tay, where a small water power has been developed. The ore is dumped from the wagons from a trestle at the mill by means of a tilting platform. It is then crushed by means of jaw crushers and rolls, and fed to a wet concentrator consisting of a revolving screw working against a current of water. Thence the graphite is taken to a revolving dryer and sized by means of screens. It is afterwards ground by mill stones to the requisite fineness. The produce is nearly all flake graphite.

Mr. R. McConnell is manager for the company, and Mr. J. Lattrell superintendent of the mill. A force of 40 men are employed at the mine and 15 men at the mill, a number of these being employed on construction work. An auxiliary steam plant is being put in at the mill.

Mica

The market for mica depends directly on the demand for electrical machinery. Although some mica is used for other purposes, still probably 90 to 95 per cent. of the mica produced in Ontario is used in the electrical trade. In consequence the market fluctuates with the fluctuations in the financial world on which the building of electric railways, and the installation of large electrical development plants depend. With the depression of 1907 all new work in the large electrical manufacturing companies was cancelled. As a result the demand for mica suddenly ceased, and consequently prices dropped. A number of the producers were also unable to get their money for the mica they had sold for some time before the depression. This necessarily caused the closing down of most of the mines, and a decreased production from those mines which remained in operation. That the effect on the industry was marked is shown by the fact that while in January, 1907, there were employed in the city of Ottawa about 1,500 hands at the several mica works, in January, 1908, there were probably not more than 100 at work.

Hanlan mica mine.

Lacey Mine

The Lacey mine, situated in Loughboro township about 4 miles from the village of Sydenham and owned by the Loughboro Mining Company, a subsidiary company to the General Electric Company, has remained in operation during the year. Very little new work has been done beyond that described in the last Report of the Bureau of Mines. The working faces are all being continued, and the lower workings of the mine are being thoroughly stoped out. As the working stopes are finished, the waste rock is dumped into them. A new deposit has been opened up in the footwall side of the old workings. A cross-cut has been driven to this body from the third level a distance of 60 feet. On this body of mica which is largely milky mica, a drift has been run southeast a distance of 35 feet. The deposit is parallel to the main body. As mentioned in the last Report a shaft is being sunk on the vein about 25 feet from the air shaft. A raise is also being driven up on the vein to connect with this shaft. The mica is rough cobbed at the mine and shipped to the General Electric Company's mica trimming works at Ottawa.

Mr. G. W. McNaughton is manager, employing a force of 25 men.

Hanlan Mine

The Hanlan mine, situated on lot 11 in the sixth concession of North Burgess and owned by the Loughboro Mining Company, has been in operation during all the year. The workings have now attained a depth of 140 feet with a length of 150 to 200 feet. Pillars are left at intervals for a support to the walls, and stulls heavily lagged are put in about every 25 feet as a further protection to the workmen. A drift is being driven from the bottom of the shaft along the vein to the west, which consists of pink calcite carrying some mica crystals. No exploratory work has hitherto been done on this side of the shaft. Some diamond drilling was done during the year with the view of testing the continuity of the deposit. The mica is rough cobbed at the mine and shipped to the General Electric Company's mica trimming works at Ottawa. A new 80-h.p. return tubular boiler was installed during the year.

Mr. G. W. McNaughton is manager, and Mr. S. Cordick superintendent, employing a force of 20 men.

Smith Mine

The Smith mine, situated on lot 13 in the fifth concession of the township of North Burgess and owned by the Dominion Development and Improvement Company, is a producer both of mica and apatite. The mine has been in operation during the year, and the pit has been sunk to a depth of 65 feet following the mica. The first 25 feet of the pit is vertical, from which point it has a dip to the west of 45 degrees. No uniform system of development has been followed, the mica occurring through the apatite and calcite so irregularly that the workings have merely followed the pockets. The workings near the bottom of the pit are about 24 feet in length by 12 feet in width. About 50 feet from the surface a pocket of mica has been followed to the north a distance of 30 feet from the main pit. A small boiler supplies power for the drill and hoist. The pit is remarkably dry, only a couple of buckets of water per day being hoisted.

Mr. Edward Smith is manager, employing a force of 15 men.

Mica Prospects

Messrs. Sewell and Smith are prospecting lot 13 in the seventh concession of North Burgess. A pit 20 feet deep has been sunk and some mica taken out. Some 6 men are employed under Mr. Terry Smith.

Messrs. McConnell and Watts are prospecting lot 12 in the sixth concession of North Burgess. The work consists chiefly in trenching.

The Brockville Mining Company mined on lot 7 in the sixth concession of Bastard township about three miles from the town of Elgin during part of the year. The pit has been sunk to a depth of about 100 feet following the dip of the vein, and has a length of 40 feet. The mica was rough cobbed at the mine and shipped to the Company's trimming works at Brockville for preparation for the market.

Messrs. Stoness and Kent were working a property on the west side of Bobb's lake during the summer. Considerable prospecting was being done in addition to working in the main pit, which is 75 fet deep by about 30 feet in length at the bottom. The mica is rough cobbed at the mine and shipped by way of Olden on the Kingston and Pembroke railway to the Kent Bros' mica works at Kingston.

Mr. J. Stoness is manager, employing about 15 men.

On lot 7 in the ninth concession of Loughboro township, the New York and Ontario Mining Company were engaged during part of the year in working a small deposit of mica known as the Freeman mine. The pit is about 60 feet deep and 40 feet in length, and has been worked as an open cut. Mr. S. Orser is superintendent in charge, employing a force of 10 men. The mica is rough cobbed and trimmed at the mine.

On the lot adjoining the Freeman mine Mr. H. Amey has been engaged part of the year in developing a mica deposit. No work was being done on it at the time of my inspection.

Mica Trimming Works

The General Electric Company's mica works are located on the corner of Bridge and Albert streets, Ottawa. The mica is obtained from the mines belonging to the Loughboro Mining Company. About 50 hands are employed at present.

The Laurentide Mica Company's factory on the corner of Queen and Bridge streets, Ottawa, was closed down during the winter, but has been reopened and at present employs about 30 hands.

Eugene Munsell and Company's works are situated at 400 Wellington street, Ottawa. At present they are doing but little.

Henderson talc mine.

The other companies engaged in this business in Ottawa and who buy mica from the small producers, are the Wallingford Mining and Mica Company on Sussex street; R. Blackburn, Sussex street; Webster and Company; and the Comet Mica Company, Wellington street.

Kent Bros. of Kingston have their works on Brock street in that city, and obtain their mica chiefly from their own mines.

J. Adams of Perth has a mica trimming shop and employs a few hands.

Marble

A new marble quarry has been opened up two miles south of Bancroft by Mr. T. Morrison. Machinery for quarrying the marble is to be installed at once.

Talc

The Henderson talc mine on lot 14 in the fourteenth concession of the township of Huntingdon was in operation for about two months in 1907, and operations have again commenced this year. The crude talc was formerly shipped to the United

States, but during this year a contract has been made to supply their talc to a mill being erected at Madoc by Mr. Gillespie, which will have a capacity of about 20 tons per 24 hours. Several grades of talc will be prepared for the trade, the market being looked for in Canada. The talc is first ground by means of a gyratory crusher, which reduces the talc to about 5-mesh. It is then passed through pulverizers, which will finally reduce it to 200-mesh. The mill is being erected near the Grand Trunk station at Madoc, the mine being distant about one mile.

The open pit at the mine is now 100 feet deep, the pit being 60 feet long and an average of 22 feet wide. Drifts have been run from this bottom level northeast 25 feet and southwest 15 feet. A new shaft is to be commenced this summer 50 feet southwest of the open cut and on the vein, and all work done from this shaft in future, the old open pit being unsafe.

Mr. S. Wellington is in charge, employing a force of 10 men.

GEOLOGY OF THUNDER BAY—ALGOMA BOUNDARY

BY ARTHUR L PARSONS

On June 4, 1907, the writer received instructions from Thos. W. Gibson, Deputy Minister of Mines, to accompany Mr. Alexander Niven, O. L. S., in his survey of the boundary line between Thunder Bay and Algoma, and to report on the geology, timber and agricultural resources of the country to be traversed. A canoe and camp equipment was provided by the Bureau of Mines, and Mr. A. C. Mitchell was employed as canoeman, in which capacity he rendered most efficient service on the trip. The next day we left Toronto and went to White River on the Canadian Pacific Railway, reaching that station June 6th. That same day in company with Mr. Niven's party, we moved the camp equipment to the beginning of the line at a point about three miles west of White River.

The Route

The original plan for the geological work was to follow the water courses from Montizambert in to the line, but on consultation with Mr. Niven it seemed better to follow the line in order to get a cross section which would permit of the rock outcrops being definitely located with respect to some given point. An additional incentive for going along the line rather than going up White lake from Montizambert was that the geology around White lake has already been mapped ([1]) and outcrops on this lake have been described and referred to the Huronian. Other outcrops of similar material were mapped at the same time on Kabinakagami lake, and it seemed probable that these rocks would be found on the line.

Inasmuch as the canoe which was provided did not arrive at Montizambert until Saturday, June 8th, and could not be brought to White river until the following Monday, delay was experienced in starting, and Mr. Niven's party was a day's trip ahead of us. The route followed was along the line for the first four miles, and in making the trip three small lakes near the two-mile post were explored. At four miles twenty-two chains the writer left the line and went to a lake about fifteen chains east of the line. The country in the first four miles is exceedingly rugged so that considerable time was lost, and on reaching the lake at four miles twenty-two chains we were about two days and a half behind Mr. Niven's party. In exploring this lake an outlet was found flowing to the north and as a river flowing from the east into Quinquaga lake had already been mapped, it seemed best to follow this outlet rather than the line. After four days' hard work we overtook Mr. Niven's party on Quinquaga lake where we camped with him near the fourteen-mile post that night. This watercourse is the worst canoe route that has been seen by the writer, and inasmuch as it was blocked by logs and alders so that it was necessary to cut a passage for the canoe, it is probable that the writer is the first white man to have gone down this creek, at least in the summer time. In these four days ten portages were cut, which varied in length from two chains up to half a mile.

After camping with Mr. Niven, the following day was devoted to exploration of the south end of Quinquaga lake; the next day the north end was examined, and we then proceeded by the outlet to the line. From this point the writer accompanied Mr. Niven's party to Obakamaga lake and examined the shores of all the lakes en route for outcrops of rock. On reaching Obakamaga lake the writer left the survey party, and examined the rocks on this lake and Trout lake for three days. After making this examination he again proceeded on the line and overtook the survey party after about a week, and accompanied them to the Pegutchewan river. On the way all the lakes, which were found, were explored, and an excursion

[1] Report of the Survey and Exploration of Northern Ontario, 1900 (Toronto, 1901.) Map accompanying the report

was made a few miles up and down the Bad river. At the Pegutchewan river the writer in company with Mr. Mitchell and Mr. Wm. Gregory, Mr. Niven's head packer, went down stream as far as the Transcontinental Railway survey line, and made notes of the rocks and timber on the route. On this river is a cache of the Transcontinetal line in charge of Mr. Brisbois, who gave us a hearty welcome. From this point we went by the railway survey line to the boundary line between Algoma and Thunder Bay and followed that to the Flint river, which we struck at a point about three miles above its junction with the Kemogami or English river. On reaching this point Mr. Niven sent out about half his men with two guides under the direction of his nephew Mr. David A. Niven. The writer accompanied this party to the post of the Hudson's Bay Company on Long lake, where he left them so as to have time to examine some of the features of the Pic river on his way to Heron bay, which was reached on September 20th. From Heron bay he proceeded to White river by rail and stopped over night. The next morning he left for Toronto where he arrived September 22nd. On the trip four dozen photographs were taken by the writer, but on account of moisture they were unfortunately all ruined.

Topography

The country between White river and the Pegutchewan river consists of a series of ridges and valleys extending parallel to the strike of the rock. The hills are from fifty to three hundred feet above the valleys, and the greatest elevation attained is about fourteen hundred feet above sea level. For the first thirty-five miles the general direction of the hills and valleys is northeast and southwest. An exception, however, is found in the north end of Quinquaga lake, which lies in a valley extending due north and south. From the thirty-fifth mile up to the forty-seventh mile the general direction of the hills and valleys is N. 70° W., but at the fifty-seventh mile the direction has changed to N. 80° E., and from this point to the seventy-eighth mile the general direction is east and west.

The entire region is glaciated and most of the hills are much rounded, but in many cases the side of the hill parallel to the dip of the rock has a gentle slope, while the other side presents a precipitous cliff. Near Obakamaga lake, and again near the fifty-three mile post, the country is quite sandy and shows no great elevation above the general level. In one place a glacial deposit in the form of a kame was noticed, but this was of small size.

In the valleys there is usually a stream or a lake and small swamps are frequent. The entire country except on burned spots and rock outcrops is covered with a heavy growth of moss and forest trees. On the assumption that in places where trees show a luxuriant growth, good agricultural ground will be found, it might be supposed that nearly the whole region would develop into a good agricultural country, but in view of the large number of rock outcrops and the fact that the soil when seen is sandy and has very little growth upon it where it has been cleared by forest fires, it would appear that the country is not adapted for agriculture.

North of the Pegutchewan river no rock outcrops were seen on the line, and the country is nearly level but is covered by a marsh. In a few places the soil was seen and found to consist of a sandy loam which will furnish an excellent soil for agricultural purposes. Owing to the lack of boring instruments it was impossible to get the depth of the swamp deposit and the soil, but in many cases the moss and peat were found to have a depth of over four feet, as seen in water holes and places where trees had been uprooted.

In the mountainous region are several rivers of fairly good size, but none of them are looked upon as good canoe routes. The Nagagami, however, is used by the Indians in going from Montizambert to Hudson bay, but the writer was warned by the guides of Mr. Niven's party not to attempt to go down it, as the rapids are dangerous and the portages not easily found. The Bad river is used to some extent

by the Indians, as was shown by the presence of several camping grounds and bark canoes along the shore. The river at 53 miles is used by the Indians who also have trapping grounds on the inlets of the lake just west. The Pegutchewan river is at present employed as a route for bringing in supplies to the Transcontinental Railway cache, and in high water is looked upon as a good route from Heron bay on the Canadian Pacific railway to Hudson bay, but in shallow water it is a very poor route, as it is full of rapids for most of its length.

On or near the line are several lakes of good size which would furnish ideal locations for summer resorts, except that at the present time they are almost inaccessible. The most important of these are Quinquaga, Obakamaga, Trout, and the lakes at thirty-three miles ten chains, fifty-four miles, and fifty-eight miles thirty-six chains. On the Bad river are two long narrow lakes which have most delightful surroundings. Other lakes which are found on the line do not as a rule exceed half a mile in length, with few exceptions have rocky or sandy shores, and contain fish in abundance.

The country from the line to Long lake is nearly level and is covered with luxuriant forest growth. Although the English river has several rapids in this distance, with a total fall of more than a hundred feet, no great elevations were noticed in the country on either side of the river. The soil where seen is a good sandy loam well adapted for all agricultural purposes. The last six or eight miles of the English river in going up to Long lake flows through a swamp covered with marsh grass, which is cut for the stock at the post of the Hudson's Bay Company.

The country around the north end of Long lake is rolling, and shows a few high hills but in looking south on the lake the elevation seemed to be greater. The route of the party, however, took us only about a mile and a half south of the outlet to where the Making Ground river enters Long lake. This river in the twelve miles from the lake to the Height of Land portage flows through a level country, much of which is covered by swamp, and shows only two rapids, neither of them having a fall of over three feet.

In coming down the Pic river the country is undulating as far as Sandy Hill falls. The hills are either sand ridges or rounded outcrops of schist and gneiss, which in many cases are largely covered with dense forest growth. In a few cases on the shores of MacKay's lake and Rabbit lake precipitous cliffs of granite and gneiss were observed. South of Sandy Hill falls the Pic river flows through a ravine which becomes deeper after passing White Otter falls and Lake Superior falls. The hills are either sand ridges or rounded outcrops of schist and gneiss, north of Sandy Hill falls.

Forests

The forest growth in the country crossed by the survey party is extremely dense, except in a few places where forest fires have cleared areas of greater or less extent near the water courses. In no case was a burned area found at any distance from the water. The trees found in this region are spruce, balsam, tamarack, Banksian pine, white cedar, birch and balm of Gilead.

Of these, spruce, both the black and white varieties, has the widest distribution. It is found extending from the Canadian Pacific railway to the English river, and was noted at most of the points where observations of forest growth were made. The reason for this wide distribution of the spruce appears to lie in the fact that it thrives not only in swamps but upon the uplands as well, and except in the poorest soil of the highest uplands it attains sufficient size to be used as pulp-wood. The largest trees are about fifteen inches in diameter, and were seen in swamp districts. The maximum height noticed was about a hundred feet. The average diameter of the trees is from six to eight inches.

Balsam is much less abundant than spruce, but has the same general distribution. In size it attains nearly the maximum noted for spruce, and shows about the same average size.

Banksian pine is quite important in this region, and in the mountainous district is second only to spruce. Few, if any, trees were seen exceeding ten inches in diameter, and the average of this tree is probably not over six inches. It is found growing almost entirely on the upland, on sandy knolls, and in the crevices of the rock. Its presence may be looked upon as an indication of sandy soil and good drainage. North of the Pegutchewan river the only places where Banksian pine appears were in burned areas near the Pegutchewan and English rivers.

Tamarack was first found in a living condition on the twenty-eighth mile, but dead trees were noticed on the outlet of the lake at five miles and on the outlet of Obakamaga lake. From the twenty-eighth mile up to the thirty-sixth mile it was seen occasionally, but the trees were not thrifty. In the forty-fourth mile this tree was again seen, and from that point to the English river it was found in greater or less abundance. The maximum diameter noted was two feet, and specimens were frequently seen having a diameter of fifteen inches; but the usual range is from eight to twelve inches in diameter. This tree is found only in swampy regions.

White cedar occurs throughout the entire region, but is not abundant. It is found on the edges of nearly all the lakes, on the banks of the streams, and in a few swamps, so that it would seem to a person travelling through the country and following the water routes, to be one of the principal trees of the region. It is, however, quite rare, as it is seldom found more than two or three hundred feet from the water's edge. The largest tree noted was about eighteen inches in diameter, but the usual range of mature trees is from eight to twelve inches.

Balm of gilead was first noted on the thirty-ninth mile and is distributed sparingly throughout the entire region from that point to the English river. On the Pegutchewan river it is one of the more abundant trees. The size of mature trees ranges from twelve to eighteen inches in diameter, and the tree attains a height of from fifty to seventy feet.

Birch and poplar are found growing together, along with Banksian pine, on sandy ridges and on burned areas from the Canadian Pacific railway up to the Pegutchewan river. They are also abundant along the shores of the Pegutchewan and English rivers, particularly on burned areas and river flats which are subject to inundation.

Aside from the timber noted above two or three trees of red pine were observed on a hill west of the outlet of the lake at five miles. Along the water courses hazel, alder and dwarf willow are abundant.

Small Fruits

The most common small fruit in the region is the blueberry or huckleberry, which is found growing principally in the crevices of rocks and on sandy knolls. It was, however, met with in some of the marshes. Near streams and lakes the bilberry is found in abundance and is one of the best fruits in the region. On sandy knolls wild strawberries were found frequently, but were not abundant. In the marshes the low bush cranberry is very plentiful, and with it the creeping snowberry is frequently found. The latter is one of the best flavored small fruits in the region. The black currant and the fetid currant are sparingly distributed, and a few red raspberries were noticed.

Fungi

Through the whole region fungi are very abundant, but the writer was unable to identify most of the varieties. The bear's head hydnum (hydnum caput ursi), and a variety of puff ball were the only edible fungi which were recognized by the writer.

Fauna

Very few animals were seen by the members of the party during the summer, but traces of various animals were quite frequent. The most abundant large animal is the moose; in all eight of these were seen by different members of the party during the summer, and they are found throughout the whole region traversed. One red deer was seen on the Pegutchewan river, and caribou tracks and runways were noticed in some abundance near the Flint river. On the shore of the lake at forty-two miles the tracks of a bear were seen.

Of the small animals, rabbits are the most abundant, and porcupine was seen on two or three occasions. Beaver is found sparingly in the region, and one dam was seen upon which the leaves of the twigs used by the beaver in building the dam had not yet wilted, so that the work must have been done within a few hours of our arrival. Two or three older dams were also observed, but none of the beaver were seen. Marten, fisher, stoat and mink are reported as abundant by Mr. Brisbois, the keeper of the Transcontinental Railway cache on the Pegutchewan river.

Domestic animals thrive, as at the Hudson's Bay Company's post at the north end of Long lake were a team of horses, two cows and a calf, chickens and ducks.

In the country traversed by the line very few birds were observed, but in clearings and near the travelled routes they are somewhat abundant. Of game birds, grouse and ducks are fairly well distributed. On several of the lakes gulls were seen, and on nearly every lake one or more pairs of loons had their habitation. The crow, raven and Canada jay are sparingly distributed throughout the region, while in clearings the song sparrow, the white-throated sparrow and the crossbill are quite abundant.

Fish

In all the lakes and rivers which were crossed fish are very abundant. The only species seen, however, were pike, pickerel, brook trout, suckers and white fish.

Water Power

On the inlet to Quinquaga lake are three rapids, the upper one having a fall of about twelve feet; the height of the other two was not taken, but as nearly as could be judged from the length of the rapid, the fall could not be less in either case than twenty feet. On going up this river beyond Lake Quematurobkistegong three rapids are found, which have a fall respectively of thirty feet, fifteen feet, and three feet. No other good water power was seen up to the Pegutchewan river, but at the point where the river turns north are two rapids with a total fall of about twenty-five feet. Although there are many other rapids in this river, they are not of sufficient height to be considered as desirable locations for water power. The rapids of the English river furnish several good water powers which have been described before [2]. On the Pic river good water power can be developed above Segiwatan lake and below Papakiney lake, above Rabbit lake and at Split Rock portage; there is also excellent power in the rapids around Dead Man's portage as well as at Sandy Hill, White Otter and Lake Superior falls.

Agricultural Land

The region south of the Pegutchewan river, being made up of a series of rocky and sandy ridges together with valleys which are usually covered with a marsh deposit, does not offer much inducement to the agriculturist. On the supposition that where forest growth is luxuriant other vegetation would thrive, it would seem that this region should furnish good agricultural land. The soil where seen is a

[2] Rep. Exploration Northern Ontario, p. 157.

sand or sandy loam, usually the latter. The underlying rocks are composed largely of orthoclase, which by its decomposition yields a certain amount of plant food. It is probable, however, that this region will give its best returns if properly forested, although regions having a similar soil are very productive along the Atlantic seaboard of the United States. Particularly is this true of the pine barrens of New Jersey. The amount of rock in this region, however, is a barrier to its development as an agricultural region.

The country north of the Pegutchewan river is at present covered with a spruce swamp, but in some places the underlying soil was seen and found to consist of a sandy loam which is most excellent for agricultural purposes. During the summer a visit was made to the Transcontinental Railway cache on the Pegutchewan river where potatoes, cucumbers, tomatoes, peas, radishes, lettuce and beans were grown, and all of them were in a thrifty condition. This country produces an excellent quality of potatoes, as is shown by those raised at the north end of Long lake each year by the Hudson's Bay Company's employees. At Long lake oats mature, and in spite of the unfavorable season the crop was doing fairly well. No effort has been made to grow forage crops, as there is an abundance of wild grass, but on the portages on the Pic river timothy and alsike clover were growing and doing well. The latter is evidently the result of accidental seeding in transporting hay for the stock at some of the Hudson's Bay Company's posts.

Geology

In the region south of the Pegutchewan river the rocks are all granite, gneisses and schists which are cut in many places by diabase dikes, and without tracing the different bodies of rock to other outcrops of known age at the east or west it is impossible to assign definitely any given age to some of them. Large masses, however, are undoubtedly Laurentian in age, and these are made up of biotite granite, pegmatite and biotite granite gneiss.

In view of the fact that a large body of so-called Huronian has been mapped on White lake, north of Montizambert, and an outcrop of hornblende schist on Kabinakagami lake has been referred to the Huronian in the report of the Survey and Exploration of Northern Ontario in 1900 [3], it seemed probable that similar rocks would be found crossing the line. Inasmuch as Huronian was made to cover not only the rocks that are now classed under that name, but also all dark rocks of greater age, the rocks which were found on the line connecting these outcrops are referred tentatively to the Keewatin. These rocks are hornblende schists or gneisses, and are found developed best on Quinquaga lake, where they constituted all the outcrops examined. So far as the material collected is concerned, it might be looked upon as a hornblendic variation of the Laurentian rocks, but in view of the fact that a line connecting the two outcrops, heretofore mapped on White lake and Kabinakagami lake, passes directly through these outcrops, it seems almost certain that the three should be considered to be of the same age. In referring them to the Keewatin the opinion of the writer is upheld by Prof. A. P. Coleman, and specimens from the contact of the Laurentian and Keewatin which were collected by Dr. Coleman near Lake Nipigon are almost identical in appearance with rocks found by the writer a short distance from Quinquaga lake as well as on the lake itself. Another strong ground for considering these rocks to be of different age from the others in the region is that at about equal distances from the main body of hornblendic rock to the southeast and northwest are narrower bands of hornblendic rock, one of which shows the contact phase mentioned above. With the exception of two isolated cases, these masses are the only outcrops of schistose hornblendic rock within twenty-five miles of this body. In one of these isolated cases the outcrop consists of a segregration of basic material, which is composed almost entirely of hornblende, enclosed in a

Map accompanying report, and p. 13'.

biotite gneiss, and the entire segregation is not more than ten feet long and two feet wide. The other isolated case is situated on the outlet of Obakamaga lake, and resembles the rocks around Quinquaga lake, so that although it is in a region where Laurentian rocks are abundant, yet as it is apparently in a syncline it is possible that it may be an outlier of Keewatin.

A large body of garnetiferous biotite granite gneiss, which lies to the north of an outcrop of hornblende schist in the forty-fourth mile, agrees so closely in its characters with Grenville gneisses from the Muskoka region that it would seem to belong to this age. The occurrence of garnetiferous biotite schist which is referred to the Huronian has been noted on Mackay's lake; this latter rock is, however, of very much closer texture, but if continued to the east it would cross the line in the general region of these outcrops. In view of the fact that rocks of known Grenville age have not yet been distinguished in this region, it will be necessary to have considerable work done in tracing these outcrops to the east and west before any definite age can be assigned to them. In this report the garnetiferous rocks are referred to the Laurentian, for the reason that the only distinctive feature which would lead to other classification, (if we except the outcrop of Huronian or Keewatin schist on Mackay's lake) is the presence of garnet in the rock. In all other points these rocks are apparently the same as the Laurentian gneisses found in other parts of the line.

At frequent intervals dikes are to be found cutting both the Laurentian and Keewatin rocks. These dikes consist of diabase, which in all cases is free from olivine, and in many instances, in addition to labradorite, augite and magnetite, contains primary quartz and biotite. Samples were taken from all outcrops of diabase, as well as from a few boulders, in the hope that some of them might contain nickeliferous pyrrhotite, but in no case was this mineral found.

In the determination of the geologic age of the crystalline rocks, the writer has been guided principally by their petrographic character, and the presence of rocks of similar age and composition at the east and west which by extension would cross the line at about the point where the rocks in question were obtained.

Sedimentary rocks were first found in place on the Flint river. These sediments consist of a limestone which is referred by the writer to the Lower Devonian.

Biotite Granite at the Start

The first rock noted in place was found near the first mile post, and is a fine grained biotite granite. In the hand specimen the rock is light gray in color, and consists principally of quartz and orthoclase in about equal proportions, together with about five per cent. of biotite. No trace of gneissic structure could be found, and the rock is without doubt Laurentian in age. Owing to slight alteration of the biotite the rock has a reddish tinge, due to the presence of small traces of iron hydroxide, but this is only seen on the weathered surface.

Near the second mile post an outcrop of this same rock is to be found, and with it are bands of pegmatite. In mineral composition this rock cannot be distinguished from the last mentioned, and the texture is the same. The pegmatite has the same mineral composition as the granite, but has crystals from an inch to an inch and a half across. This outcrop is at the top of a steep hill about two hundred and fifty feet high, and although it was apparent that the rock was very near the surface yet with the exception of the summit, the entire hill was covered with moss and sandy loam in which a good forest growth of spruce, birch and poplar were present.

At two miles sixty chains, rock of very similar character is found at the top of a cliff about two hundred and fifty feet high. The exposure here extends about a half mile east of the line and forms an almost vertical precipice facing the south. At the foot of the cliff is considerable talus. The rock at this point consists of

bands of granite and pegmatite, but except for this banded appearance, there is no trace of gneissic structure. The pegmatite is composed almost entirely of quartz and orthoclase, with a very small percentage of biotite and traces of magnetite. No thin section was made of the pegmatite bands. The granitic bands are fine grained and are rather pink, but except for the pink tinge, the rock is apparently the same as that found at the two mile post. Under the microscope the granite was found to consist of orthoclase, microcline, plagioclase, quartz, biotite and magnetite. The orthoclase is considerably kaolinized and shows inclusions of limonite, which accounts for the pink color of the rock. The plagioclase approaches andesine in the angle of extinction, and apparently grades into orthoclase. The quartz shows no crystal outline, but is considerably rounded and contains numerous liquid and gaseous inclusions.

This same rock is found outcropping near the three mile post and at three miles twenty-five chains, and in the latter place exhibits a peculiar feature of differential weathering. Two blocks of granite about three feet high and three feet square at the base are situated about six feet apart, and are the only prominences to be seen.

At three miles fifty chains is a nearly vertical cliff of the same granite. On the top of this cliff a dike about three or four inches across was noted. In the hand specimen the rock is felsitic, but shows some small phenocrysts. In color it is dark greenish brown to black, and the specimen is considerably weathered so that the brown color is evidently due to oxidation of iron. Microscopically, the rock is porphyritic, and contains phenocrysts of idiomorphic augite and a feldspar which has been altered almost entirely to calcite. The ground mass consists of quartz, microlitic plagioclase and biotite. The granite found at this point continues to about four miles ten chains.

Gneiss Outcrops

At four miles twenty-two chains we turned east to a lake which is about fifteen chains east of the line. This lake is about a mile and a half long and is shaped very much like a Greek cross. The main part of the lake extends almost north and south, while the east and west arms extend about N. 50° E. The inlet of this lake was not seen by the writer, but the outlet flows from the northeast arm. At numerous places about the shores of this lake outcrops of biotite gneiss were found, with a strike of N. 40° E., dip 70° N.W. At the north end of the lake is an exposure of syenite containing considerable epidote, which is apparently intruded in the gneiss and has a strike of N. 30° E. These rocks are both referred to the Laurentian. On the west arm of the lake near the five-mile post is a dike about a hundred feet wide. Microscopically, the rock is granitic and shows lath-like crystals of plagioclase, magnetite and pyrite. The other dark minerals could not be determined in the hand specimen. The color of the rock is dark green to black, but is mottled with light spots which are possibly quartz and calcite. Under the microscope the rock is seen to consist of labradorite, pyroxene, quartz, magnetite, pyrite, biotite and secondary calcite and chlorite. The labradorite is hypidiomorphic, and forms an interlaced network of polysynthetically twinned, lath-like crystals which include in their interstices the remaining minerals. The pyroxene is quite bright and exhibits no crystal outline; in a few cases it is found altering to chlorite. The quartz is clear and exhibits liquid and gaseous inclusions, but is present in only small quantities. Magnetite and pyrite are fairly abundant, but show no distinct crystal outline. Biotite is present in very small quantities, and is usually partially altered to chlorite.

On leaving this lake we followed the outlet to a small lake on the Scaborik river which flows into Quinquaga lake. An outcrop of gneiss was noted about a mile from the mouth of the outlet of the lake at five miles, but no other rock was found in place until we came into the main river, where at a point about two miles east of the nine-mile post an outcrop of quartz diorite schist, varying in texture from very compact to granitic, was found on the east side of the river at a rapid which has a fall of about

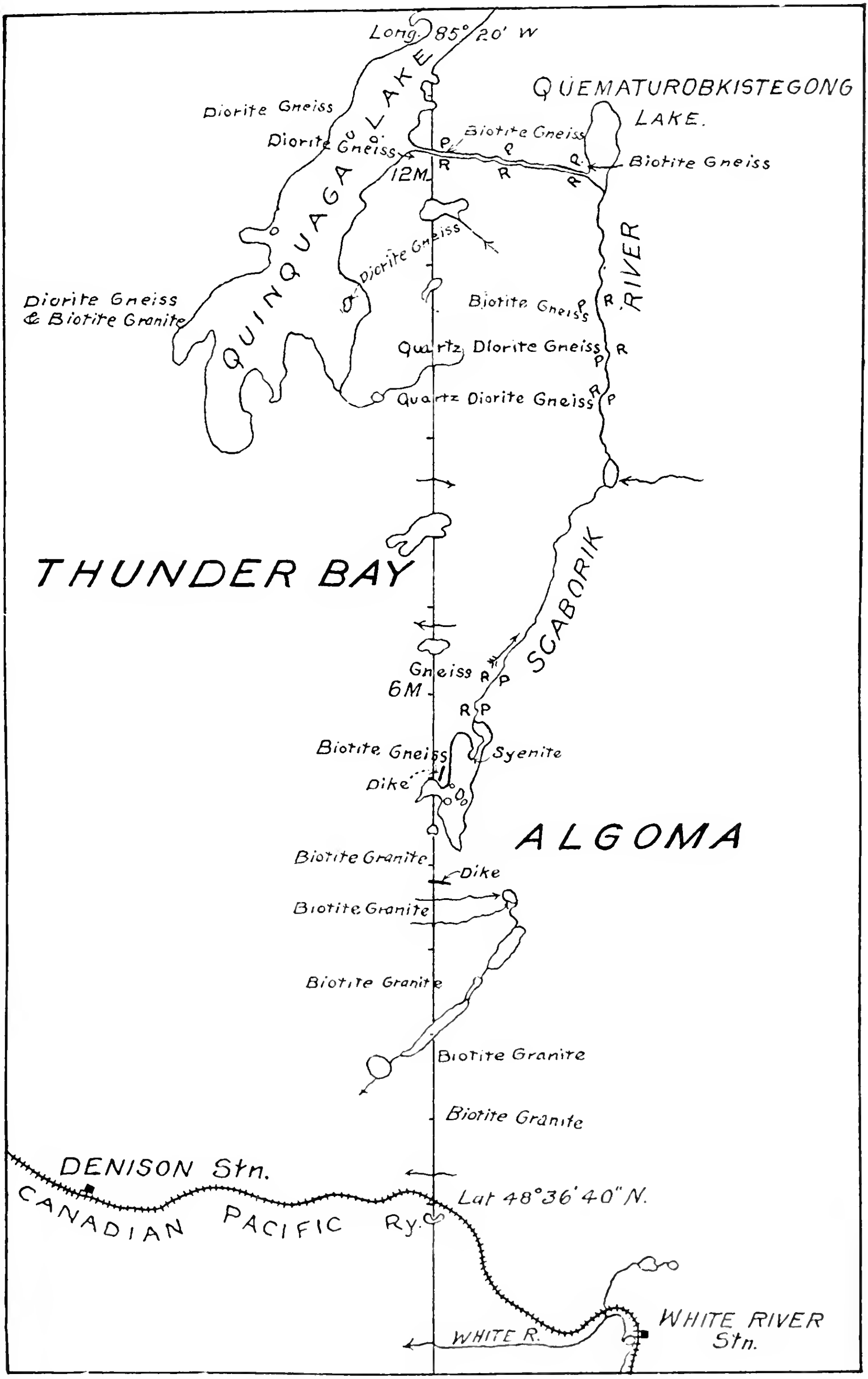

Long. 85° 20' W
QUINQUAGA LAKE
QUEMATUROBKISTEGONG LAKE.
Diorite Gneiss
Diorite Gneiss
Biotite Gneiss
Biotite Gneiss
12M.
Diorite Gneiss
Diorite Gneiss & Biotite Granite
Biotite Gneiss
RIVER
Quartz Diorite Gneiss
Quartz Diorite Gneiss
THUNDER BAY
SCABORIK
Gneiss
6M.
Biotite Gneiss
Syenite
Dike
ALGOMA
Biotite Granite
Dike
Biotite Granite
Biotite Granite
Biotite Granite
Biotite Granite
DENISON Stn.
CANADIAN PACIFIC Ry.
Lat 48° 36' 40" N.
WHITE R.
WHITE RIVER Stn.

Plate I.

twelve feet. This schist shows in the hand specimen of the coarser material hornblende, quartz, orthoclase and plagioclase. Under the microscope the fine grained material shows hornblende, quartz, orthoclase, magnetite and traces of chlorite. The hornblende is very minute and in some cases idiomorphic, but the other minerals show no crystal outline. About a quarter of a mile further north is another outcrop of quartz diorite gneiss, which is on the west side of the river near a rapid having a total fall of about twenty-five feet. This rock is distinctly banded and consists of hornblende, quartz, orthoclase and plagioclase. In texture, the hand specimen is granitic, and the entire exposure is referred to the Keewatin. About a mile farther north, and at a rapid having a fall of twenty-five to thirty feet, biotite gneiss of Laurentian age is found associated with pegmatite. This gneiss is made up of quartz and orthoclase with about ten per cent. of biotite and chlorite.

On the first portage after leaving Quematurobkistegong lake is a dark biotite gneiss, with strike N. 30° E., and the dip nearly vertical. No sample of this was taken, as it apparently was of the same composition as the rock at the last outcrop mentioned. At this point is a rapid or fall with a total drop of about twelve feet, which would furnish very good waterpower. Two other rapids were noted between this point and Quinquaga lake, but the writer was unable to estimate the height, as it was necessary to cut portages from a quarter to a half a mile long, and the entire rapid could not be seen from any one point in either case. At the lower rapids, at a point about twenty chains east of the line at twelve miles twenty chains, is a gray gneiss composed of biotite, quartz and orthoclase. This rock is almost granitic in texture and although a certain banding is to be seen, it was not sufficiently distinct to permit of accurate observations as to strike and dip. The rock appears as a ridge extending almost north and south.

Diorite Schist on Quinquaga Lake

Just south of the inlet of Quinquaga lake and about twenty chains west of the twelve mile post is a compact diorite schist, which in the hand specimen appears almost identical with the rocks found by Prof. Coleman near lake Nipigon and referred by him to the contact zone of the Laurentian and Keewatin. In the hand specimen this rock is seen to be banded, the darker bands being made up of hornblende and orthoclase, and the lighter bands of quartz and orthoclase. In texture the rock is compact to fine granitic. Under the microscope the dark bands are found to be composed of green hornblende, which represents from sixty to seventy per cent. of the rock. The remainder is made up principally of orthoclase which is altering to kaolin, but one or two particles of a plagioclase which approaches andesine in angle of extinction were observed. No quartz was seen in the thin section, although a few particles were noted in the hand specimen near the contact of the light and dark bands. The strike of this rock is N. 40° E., and the dip is nearly vertical, so that if this rock were produced it would be found outcropping only a few chains west of the biotite gneiss, which was found north of the lower rapids of the inlet to this lake.

On an island about a mile west of ten miles forty chains diorite schist is again found, having the same strike as the last mentioned outcrop. This rock shows bands of quartzose material, apparently the same as the light bands of the last mentioned outcrop. In the hand specimen the dark bands are found to be identical in appearance and in mineral composition with the rock from the last mentioned outcrop. In weathering, the feldspars in both cases were pink to brown, and the hornblende shows very little alteration. In the outcrop under consideration the hand specimen shows hornblende and orthoclase. Under the microscope the hornblende is found to comprise about sixty per cent. of the rock, the balance being kaolinized orthoclase, with a few particles of quartz and pyrite. About two miles west of this last outcrop, is another outcrop of hornblende gneiss of granitic texture. This rock consists of bands which in the hand specimen are apparently composed of hornblende and orthoclase alternating with narrower bands made up of quartz, orthoclase and small amounts of biotite. The

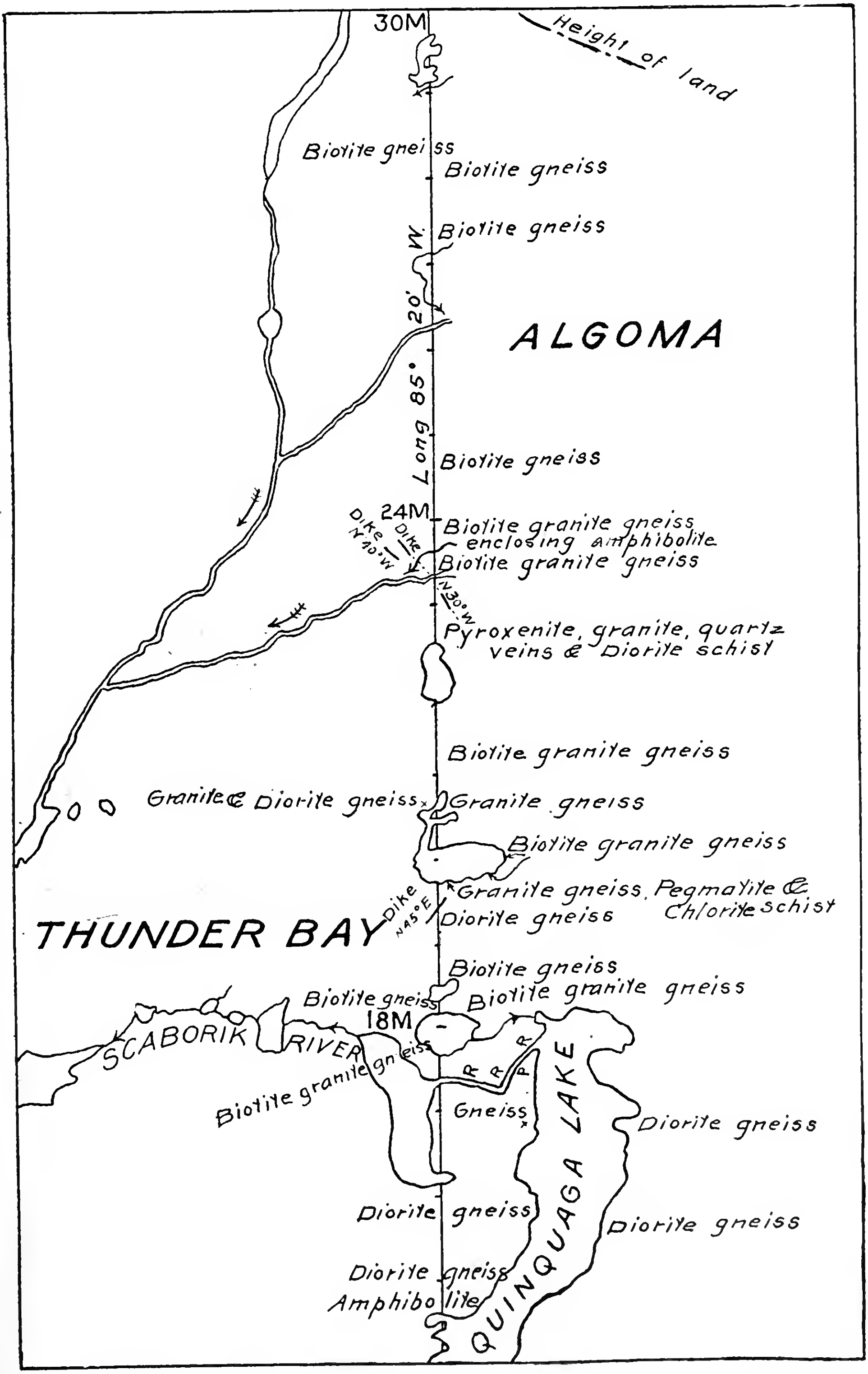

30M
Height of land
Biotite gneiss
Biotite gneiss
Biotite gneiss
Long 85° 20' W.
ALGOMA
Biotite gneiss
24M
Dike N.40°W
Dike
Biotite granite gneiss enclosing amphibolite
Biotite granite gneiss
N.30°W.
Pyroxenite, granite, quartz veins & Diorite schist
Biotite granite gneiss
Granite & Diorite gneiss
Granite gneiss
Biotite granite gneiss
Granite gneiss. Pegmatite & Chlorite schist
Dike N45°E
Diorite gneiss
THUNDER BAY
Biotite gneiss
Biotite gneiss
Biotite granite gneiss
18M
SCABORIK RIVER
R R R
Biotite granite gneiss
Gneiss
QUINQUAGA LAKE
Diorite gneiss
Diorite gneiss
Diorite gneiss
Diorite gneiss
Amphibolite

Plate II.

darker material when viewed under the microscope shows green hornblende, a small amount of quartz, orthoclase and a few particles of magnetite. The hornblende is distinctly pleochroic. The orthoclase is much kaolinized, and shows some traces of iron hydroxide which gives a pink tinge to the hand specimen. A few crystals of plagioclase were noted, and scattered throughout the mass are small crystals which appear to be apatite. This rock like the last mentioned has a strike of N. 40° E., and a dip nearly vertical.

On a point about twenty chains east of fourteen miles fifty chains is a basic phase of this rock. At this point the rock apparently is made up almost entirely of hornblende with a few streaks of quartz and orthoclase, and may be classed as an amphibolite. Very little trace of gneissic structure was noticed here, though about ten chains farther north the rock is distinctly gneissic. A point of interest connected with this basic phase is that it is about the centre from north to south of the hornblendic rocks, and may possibly be a basic segregation. Under the microscope this rock is found to be almost entirely composed of hornblende with a very little kaolinized orthoclase as its only other constituent. Although quartz was seen on one side of the hand specimen in masses of fairly good size, no trace of it could be found in the thin section.

Outcrops of diorite gneiss were also noted on the lake shore two miles east of fifteen miles twenty chains, one mile east of the sixteen-mile post, and two miles east of the seventeen-mile post, but no samples of these outcrops were taken, inasmuch as they exhibited no peculiarities to distinguish them from those at the south end of the lake. It is worthy of note, however, that the rocks at the north end of this lake have a strike of nearly north and south with the dip nearly vertical, and the general direction of the lake changes with the alteration in the strike of the rocks so that while the south end of the lake extends nearly N. 40° E., the north end extends almost due north and south.

On leaving Quinquaga lake three short rapids are found between this point and the line, but none of these are more than three or four feet high, and in only one case was it necessary to portage.

On the south shore of a small lake at seventeen miles fifty chains is a granitic gneiss composed of quartz and orthoclase with a very small amount of biotite. In addition to these constituents considerable epidote and a few particles of pyrite are present in the rock. On the northeast shore of this same lake is biotite gneiss which in the hand specimen appears distinctly banded. The rock is quite fresh in appearance, and contains about twenty per cent. biotite, the balance being quartz and a feldspar, probably orthoclase. This rock strikes N. 45° E., and dips 45° S.E. Both of these outcrops are to me referred to the Laurentian.

Keewatin-Laurentian Contact

About three-quarters of a mile east of eighteen miles twenty chains is a banded diorite gneiss of granitic texture. The rock is made up of narrow bands of dark material composed almost entirely of hornblende and orthoclase, while broader bands consist largely of orthoclase with small amounts of quartz and a few particles of biotite. This exposure is probably Laurentian, though it is quite close to the contact of the Laurentian and Keewatin.

At eighteen miles thirty chains and again at nineteen miles outcrops of biotite gneiss were found which are of Laurentian age.

At nineteen miles ten chains a compact diorite schist occurs which shows the contact phase between the Keewatin and Laurentian before mentioned as being like that found by Prof. Coleman near lake Nipigon.[4] This rock has a strike N. 25° E. and dip 60° N.W. In the hand specimen it appears banded, the darker bands being composed largely of black hornblende with somewhat altered orthoclase associated with it. The lighter bands are olive green in color, and show green hornblende with orthoclase. Under the

[4] See p. 100.

microscope the rock is found to be composed of about sixty per cent. hornblende and the remainder about equally divided between quartz and orthoclase. This same rock is found outcropping at nineteen miles twenty chains.

At nineteen miles forty-five chains is a dike with a strike of N. 45° E. The borders of this dike were not seen, so that its width is unknown. The color of this rock is dark brownish green and it shows lath-like plagioclase, magnetite and augite in the hand specimen. In texture it is fine granitic, or as the crystals of plagioclase are lath-like, we might say diabasic. Under the microscope the rock is found to be composed of labradorite, augite, magnetite, pyrite, quartz and secondary calcite and chlorite. The labradorite is largely altered to calcite but shows that it was formed in lath-like crystals which enclose the other minerals in its interstices. The augite is altered on the edges to chlorite and shows considerable twinning. The quartz contains liquid and gaseous inclusions.

On the south side of the lake at twenty miles are three outcrops of Laurentian gneiss and granite. The most westerly outcrop is composed of bands of granite gneiss, pegmatite and chlorite schist. An outcrop of similar material was found on the line at nineteen miles sixty-six chains. The strike of these rocks is about N. 30° E., although local variations are found. Samples from the outcrop on the lake show the granitic and pegmatitic bands to be composed of quartz, orthoclase and biotite. The chloritic material is composed almost entirely of chlorite, which is derived from the alteration of hornblende and is possibly a bit of included Keewatin rock. The other two outcrops on the lake are fine grained biotite granite gneiss, which in the hand specimen shows very little trace of the gneissic structure. The rocks are composed of quartz, orthoclase and biotite, and in places traces of epidote are found. A thin section of the rock at the east end of the lake shows orthoclase, plagioclase, quartz, biotite and titanite. The orthoclase is considerably decomposed, showing kaolin along the lines of cleavage of the crystal particles. The plagioclase is apparently andesine.

At the east side of the lake at twenty miles forty chains is a granite gneiss containing epidote. Directly west of this on the west shore of the lake is a granite containing inclusions of diorite gneiss. The granite is supposedly Laurentian in age, while the hornblendic rock is probably Keewatin. A sample taken at the contact and containing both rocks shows in the granite quartz, orthoclase, biotite and traces of hornblende. The diorite gneiss is apparently made up almost entirely of hornblende with some feldspar. A thin section at the contact shows the granite to be made up of quartz, orthoclase, plagioclase, biotite, hornblende, titanite and a trace of magnetite. The orthoclase is considerably altered to kaolin. The plagioclase is apparently andesine. The diorite gneiss is composed of about sixty per cent. hornblende, with the balance orthoclase and plagioclase. The orthoclase in this rock is not so much altered as in the granite.

At twenty-one miles ten chains is an outcrop of biotite granite gneiss which is almost level and is only at a slight elevation above the surrounding swamp. The rock has evidently been worn smooth by glacial action, but the surface has been decomposed to some extent, so that polishing and glacial striæ were not observed. The strike of this rock is N. 50° W., but on account of the level surface the dip could not be taken.

A Complex Outcrop at 23 Miles

On top of the mountain at twenty-three miles is an exposure of an altered pyroxenite which is cut by granite and quartz veins enclosing diorite gneiss. This complex outcrop probably represents both Laurentian and Keewatin rocks. A few chains east of the line at about twenty-three miles ten chains this complex rock is cut by a dike about two hundred feet wide striking N. 30° W., and having a nearly vertical dip. In texture the rock from this dike is fine granitic and it shows plagioclase, pyrite and magnetite, but the other dark minerals cannot be identified in the hand specimen. Under the microscope the rock is found to consist of labradorite, augite, magnetite,

pyrite and chlorite. The labradorite forms the characteristic intergrown network common in a diabase. The augite is usually bright and without any crystal outline, having been formed in the interstices in the labradorite. The magnetite and pyrite are irregular in outline, and apparently were formed after the labradorite, as they enclose in one or two instances crystals of the latter.

About half a mile west of the line at twenty-three miles fifty chains is another outcrop of diabase, which has the same strike and dip and is about two hundred feet across About ten chains west of this exposure is a dike about three hundred feet across with the strike N. 40° W. and dip vertical. This latter exposure consists of a rock which in texture is almost identical with the one at twenty-three miles ten chains, and under the microscope the same minerals are found, but the feldspars are less altered. The dike to the east is finer grained than either of the other two outcrops, and the only minerals which can be distinguished in the hand specimen are plagioclase and a few particles of pyrite. Under the microscope this last rock is found to show a characteristic network of labradorite with pyroxene and magnetite in the interstices. Considerable secondary calcite is present owing to the partial decomposition of the labradorite, and the pyroxene shows some alteration to chlorite on the edge of the crystals. These dikes cut a biotite gneiss which is interbanded with pegmatite and which has a strike N. 30° E. The pegmatitic bands are composed almost entirely of orthoclase with small amounts of quartz. The gneissic material is the characteristic biotite granite gneiss of Laurentian age.

This same gneiss occurs on the line at twenty-three miles seventy chains, and at that point contains a segregation of coarse-grained amphibolite, which is about two feet wide and ten feet long. Under the microscope this amphibolite is found to consist almost entirely of hornblende containing inclusions of biotite and orthoclase. A very little quartz is also present. In view of the fact that granite enclosing diorite gneiss was found at the twenty-three mile post, it is but fair to assume that this apparent segregation may be but an inclusion of Keewatin rock which has re-crystallized somewhat slowly.

Biotite Gneiss

Biotite gneiss which apparently is of the same age as that found at twenty-three miles seventy chains is found at twenty-four miles sixty chains and continues from that point about ten chains to the north. It is again found at twenty-seven miles twenty chains, and at this point is quite contorted, showing what is apparently cross-bedding or the formation of lenticular masses. On account of this contortion it was impossible to get the dip, but the general strike of the rock is about N. 20° E. The rock is composed of quartz, orthoclase, biotite and a few particles which appear to be hornblende.

At twenty-seven miles seventy chains is a large exposure of biotite gneiss having a strike of N. 30° E., and dip 73° S.E. This outcrop extends from about twenty-seven miles sixty-six chains to a little beyond the twenty-eight mile post, and was followed for about five chains east and west of the line. A few streaks of pegmatite were found near the southern edge of the exposure, but in general the rock is of a fine granitic texture showing its gneissic character only in the field. The rock is light gray in color and is similar in appearance to Barre granite. At about twenty-eight miles twenty-five chains is what is apparently a continuation of the same rock, but the strike is N. 55° E. and the dip 40° N.W., so that between these two outcrops we apparently have the eroded summit of a tilted anticlinal fold similar to one noted later.[5] Most of the rock at this point consists of quartz, orthoclase and biotite, forming a rock of fine granitic texture, which in the hand specimen cannot be distinguished from the rock last mentioned. A few segregations of coarse hornblende were noted, but these do not seem to form any essential part of the rock mass, and are probably to be considered as included rock fragments of slow re-crystallization.

[5] See p. 118.

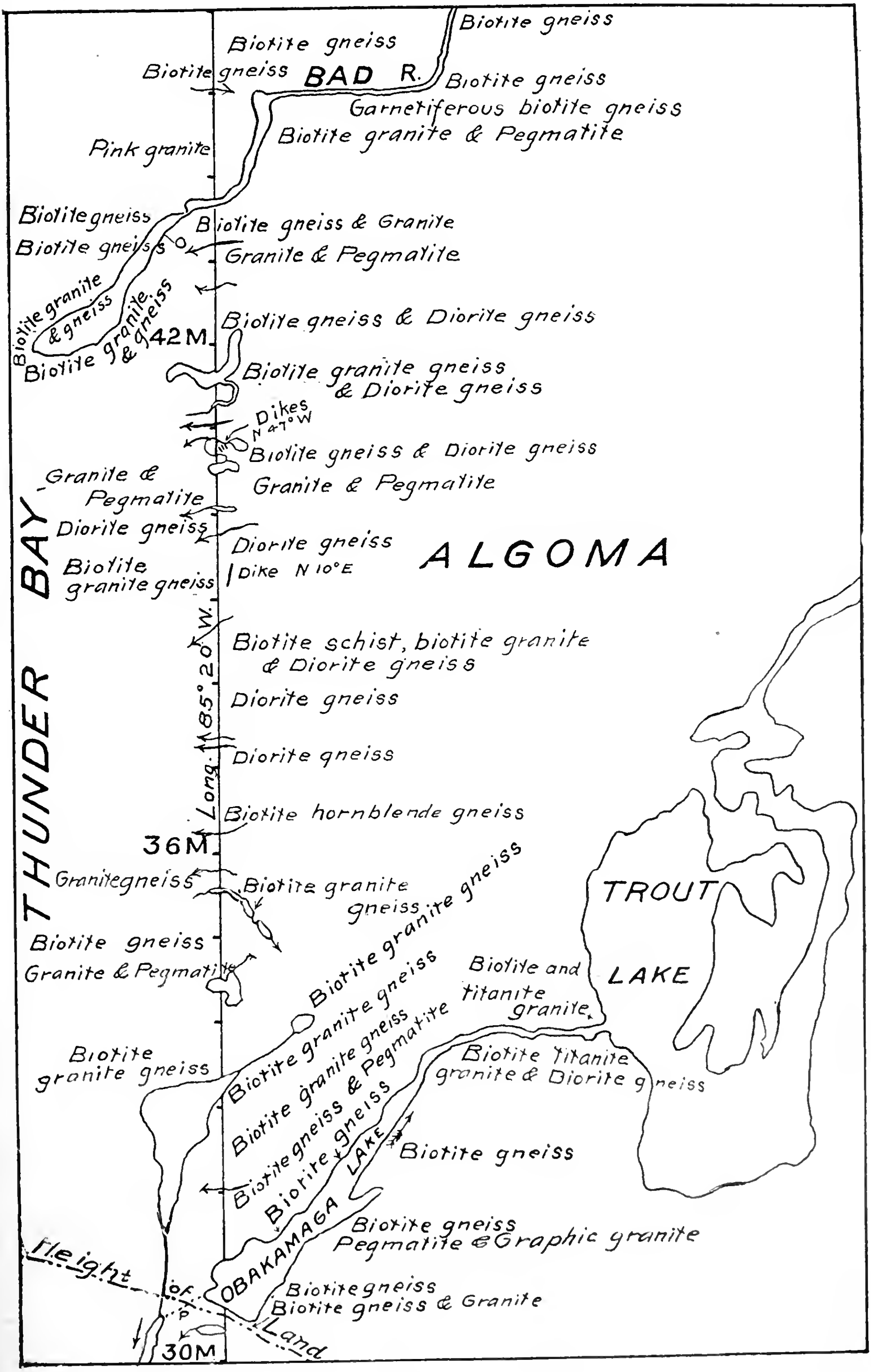

Biotite gneiss
Biotite gneiss
Biotite gneiss
BAD R.
Biotite gneiss
Garnetiferous biotite gneiss
Biotite granite & Pegmatite
Pink granite
Biotite gneiss
Biotite gneiss & Granite
Biotite gneiss
Granite & Pegmatite
Biotite granite & gneiss
Biotite granite & gneiss
Biotite gneiss
42 M.
Biotite gneiss & Diorite gneiss
Biotite granite gneiss & Diorite gneiss
Dikes N 47° W
Biotite gneiss & Diorite gneiss
Granite & Pegmatite
Granite & Pegmatite
Diorite gneiss
Diorite gneiss
ALGOMA
Biotite granite gneiss
Dike N 10° E
THUNDER BAY
Long. 85° 20' W.
Biotite schist, biotite granite & Diorite gneiss
Diorite gneiss
Diorite gneiss
Biotite hornblende gneiss
36 M.
Granitegneiss
Biotite granite gneiss
Biotite granite gneiss
TROUT LAKE
Biotite gneiss
Granite & Pegmatite
Biotite and titanite granite
Biotite granite gneiss
Biotite granite gneiss
Biotite titanite granite & Diorite gneiss
Biotite granite gneiss & Pegmatite
Biotite gneiss
Biotite gneiss
Biotite gneiss
OBAKAMAGA LAKE
Biotite gneiss
Pegmatite & Graphic granite
Height of Land
Biotite gneiss
Biotite gneiss & Granite
30 M

Plate III.

From this last mentioned outcrop up to thirty miles twenty-five chains the country is sandy, in some cases sandy loam, and no rock outcrops were noted. At this last mentioned point, however, there is a small lake about half a mile long, which has at its east end an outcrop of biotite gneiss associated with granite. The exposure is small and not well enough developed to show the strike and dip. From this lake to Obakamaga lake the country is covered with a sandy loam. Going east on Obakamaga lake rock outcrops are found very frequently, but all of them are composed of biotite gneiss, granite, pegmatite and syenite, which are undoubtedly Laurentian in age. About two miles east of the line on the south shore of the lake a small amount of graphic granite was found in an exposure of pegmatite. This material is almost fibrous in texture, the fibres of quartz and orthoclase being from one to two millimetres across and about three inches long. Aside from this occurrence of graphic granite no peculiar features were noted in the rocks on this lake which would distinguish them in any way from the rocks found on the first four miles of the line and at other places which are not near hornblendic rocks. About fifteen chains east of the line the rock strikes N. 30° E., and dips 70° S.E. About four miles east of the line the strike is N. 30° E., and the dip is to the northwest, probably about 30°, but as the only place where the dip could be taken was under water it was impossible to get it exactly. About a mile farther east, however, a dip of 30° was found.

About midway between Obakamaga lake and Trout lake is a small outcrop of rock which is very much contorted and looks almost like a fused conglomerate. The bulk of the rock is acid in character, while some bands and lenticular masses are extremely basic. The more basic portions are essentially diorite and are made up of hornblende, orthoclase and plagioclase. No quartz could be found, either in the hand specimen or under the microscope in this portion of the rock. The more acidic portions consist of orthoclase, plagioclase, biotite and titanite, with a few particles of quartz, and the rock is evidently a biotite syenite. The biotite is altering to chlorite. The orthoclase is considerably kaolinized so that in the hand specimen it appears white. The titanite is idiomorphic and is evidently the first mineral to separate from the magma. The bulk of the exposure is undoubtedly Laurentian, but it is probable that the diorite is included Keewatin.

Biotite Titanite Granite at Trout Lake

On the west side of Trout lake is an outcrop of biotite titanite granite or granite gneiss, in a nearly horizontal position, but dipping slightly to the southeast. In the hand specimen this rock is seen to be composed of quartz, orthoclase, titanite and a small amount of biotite. The dark minerals probably do not compose more than five per cent. of the rock. A prism and orthodome are visible in some of the crystals of titanite, and as these crystals are perfect in outline while the rest of the rock is made up of minerals which do not have distinct crystals, it is evident that this is the first mineral to separate from the magma. This rock is especially interesting as the only one found on the trip in which well formed crystals of any kind occur. The most abundant mineral in this rock is orthoclase and with it is associated plagioclase which extinguishes at about 4° to 6°.

On coming back to the line the first half mile north of Obakamaga lake showed no outcrops of rock, the country being covered with a good sandy loam. The country slopes gradually upward and at thirty-one miles seventy chains there is an outcrop of biotite granite gneiss which has a precipitous cliff about fifty feet high on the north side. The rock at this point varies in texture from a biotite schist to a pegmatite, but on account of its contorted nature the dip and strike could not be taken. The minerals composing these rocks are biotite, quartz, orthoclase and magnetite, all of which are visible to the naked eye. At thirty-two miles forty chains an outcrop of very similar gneiss is found which forms a ridge running in a northeast and southwest direction down to the lake, about a quarter of a mile west of the line, and extending parallel to the inlet of this lake for nearly a mile east of the line.

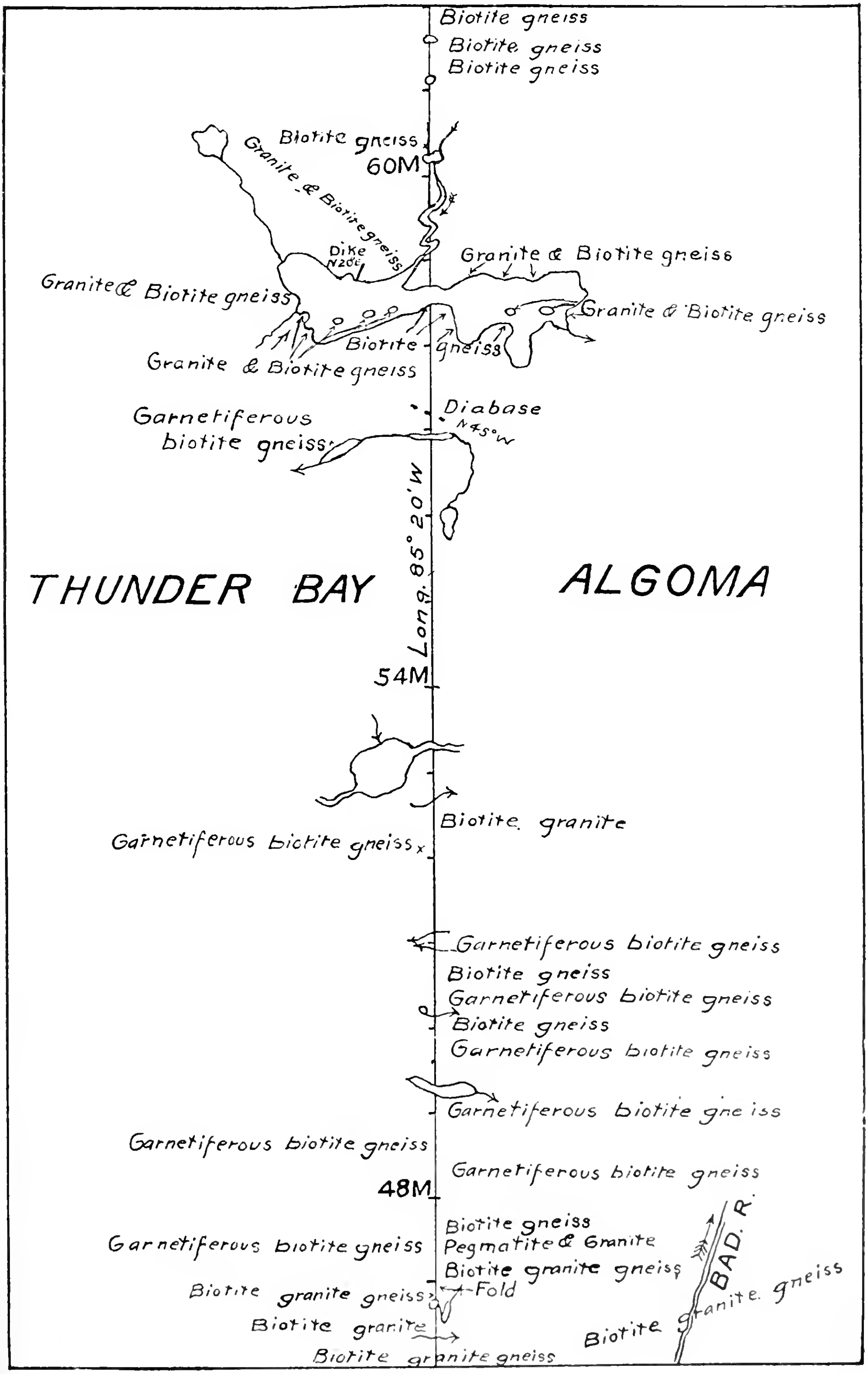

Biotite gneiss
Biotite gneiss
Biotite gneiss
Biotite gneiss
60M
Granite & Biotite gneiss
Dike N20E
Granite & Biotite gneiss
Granite & Biotite gneiss
Granite & Biotite gneiss
Biotite gneiss
Granite & Biotite gneiss
Garnetiferous biotite gneiss
Diabase
N45°W
Long. 85° 20' W
THUNDER BAY
ALGOMA
54M
Biotite granite
Garnetiferous biotite gneiss
Garnetiferous biotite gneiss
Biotite gneiss
Garnetiferous biotite gneiss
Biotite gneiss
Garnetiferous biotite gneiss
Garnetiferous biotite gneiss
Garnetiferous biotite gneiss
Garnetiferous biotite gneiss
48M
Biotite gneiss
Garnetiferous biotite gneiss
Pegmatite & Granite
Biotite granite gneiss
Biotite granite gneiss
Fold
BAD R.
Biotite granite gneiss
Biotite granite
Biotite granite gneiss

Plate IV.

At thirty-three miles ten chains is a large outcrop of biotite gneiss which shows alternating bands of fine and coarse granite. In some cases the rock approaches pegmatite in character. In the hand specimen the fine grained material is seen to consist of orthoclase, quartz, biotite and occasionally grains of magnetite, while the coarser material consists almost entirely of quartz and orthoclase. Under the microscope the finer material exhibits orthoclase, plagioclase, quartz, biotite and muscovite. The orthoclase is considerably decomposed, giving rise to kaolin and small amounts of iron hydroxide. The plagioclase shows the extinction angle of andesine. Hand specimens of the rock show almost no traces of the gneissic structure though it is quite prominent in the field. The strike is N. 45° E. The outcrop extends for nearly half a mile north of this point. On the small lake about a mile east of the thirty-four mile post a ridge of apparently the same rock is found outcropping in the north shore, although no outcrops were noticed between these two. Another outcrop of what was apparently the same rock was found on the line at thirty-four miles twelve chains. This outcrop has the same strike as those last mentioned.

On the north shore of a small lake at about thirty-four miles forty chains an outcrop of gneiss and pegmatite is found. The rock is well exposed here and exhibits glacial striæ with a direction of N. 32° E. The strike of the rock is N. 45° E., dip 30° S. The hand specimen shows orthoclase, quartz, biotite and titanite. Near the thirty-five mile post, similar rock is found which shows a distinct gneissic character in the hand specimen and has a strike of N. 45° E. In this rock no titanite was observed. The same rock continues up to thirty-five miles ten chains where the summit of the ridge between the lake at thirty-four miles forty chains and the lake at thirty-five miles forty chains is found.

Gran te Gneiss and Hornblende Gneiss

The lake at thirty-five miles forty chains extends in a northwest and southeast direction and is a little more than half a mile long. The outlet is at the southeast, and it flows into another small lake having the same direction and extending for about a quarter of a mile to the southeast. On the west end of the upper lake is a rounded mass of granite gneiss, while on the north side of the lake about ten chains east of the line is an exposure of gneiss which has a granitic texture. In the hand specimen this rock shows quartz, feldspar and biotite. The rock is quite dark on the exposed surface and this dark color is possibly due in part to smoke from forest fires, though much of it comes from oxidation of iron present in the rock. Under the microscope the minerals composing the rock are found to be quartz, orthoclase, plagioclase, biotite, titanite and secondary chlorite. The orthoclase is considerably kaolinized and shows much limonite included with the kaolin. The plagioclase is apparently andesine. The titanite is idiomorphic and apparently was the first mineral to crystallize. The biotite is largely altered and is giving place to chlorite. The rock is much brecciated and shows cracks, filled with fragmental material, which extend entirely across the thin section. Although this rock has been so shattered, there apparently has been very little gliding along the lines of fracture as crystals of quartz and orthoclase which have been broken and separated by a band of fragmental material about one-tenth of a millimeter wide, show less than one-fiftieth of a millimeter movement in a lateral direction. Except for this brecciation and recementing the rock appears to be a typical granite. Other outcrops of similar material are found a little farther east on the shore of this lake and on the line up to about thirty-six miles forty chains.

At thirty-six miles forty chains the rock changes in its character, and the outcrops up to thirty-seven miles seventy-eight chains show hornblende gneiss together with hornblende biotite gneiss and pegmatite. The greater part of these outcrops is looked upon by the writer as Laurentian, but the hornblende gneiss is considered to be Keewatin.

At thirty-eight miles forty chains is a large exposure of rock composed of biotite schist, biotite granite and hornblende gneiss. This mass of rock is much distorted so

that it is impossible to get the strike and dip, but the ridge runs N. 30° E. In some places the banding of the gneiss corresponds in general direction to that of the ridge, but in other places it extends in an east and west direction. The biotite granite and gneiss are apparently the same in mineral composition and consist of quartz, orthoclase and biotite. The hornblende gneiss is very similar in appearance to that found near the inlet of Quinquaga lage about twenty chains west of the twelve-mile post. It, however, contains only about fifty per cent. hornblende, the balance being made up of orthoclase. This hornblendic material is probably an intrusion of Keewatin in Laurentian gneiss.

A Boulder-strewn area

Five chains farther north is a creek flowing nearly west through a valley which broadens out to the west and northwest into a flat nearly half a mile wide. The soil of this flat is a sandy loam but is strewn with glacial boulders. The entire region here for a mile or two, and in fact most of the way back to the lake at thirty-five miles forty chains, has been stripped by forest fires, and for much of the distance the country is strewn with fallen timber which renders it exceedingly difficult to travel even without a load. The country between this creek and the mountain which looms up at thirty-nine miles twenty-five chains has been almost entirely cleared of forest growth, and at the same time the fallen timber has been burned, so that the nature of the soil could be observed. Although the latter was a fairly good sandy loam, it was covered with boulders, and in all probability represents the condition which would be found in most of the valleys up to this point, were they cleared out.

At thirty-nine miles twenty-five chains on the south side of the mountain is a dike about twelve feet wide cutting biotite granite gneiss. The dike strikes N. 10° E., and dips 85° W. The gneiss strikes about N. 60° E., and dips about 75° S.E. This gneiss is a typical example of the Laurentian gneisses and is composed of quartz, orthoclase and biotite, and in addition small amounts of titanite which are visible to the naked eye. Associated with the gneiss are bands of pegmatite which contain the same minerals as the granite, except that no titanite was observed. The dike is dark green to black, and in the hand specimen is almost felsitic, but lath-like crystals of plagioclase can be distinguished, though none of the other minerals can be determined in the hand specimen. Under the microscope the rock is apparently porphyritic and shows labradorite, augite, quartz and magnetite. The augite is nearly colorless and occurs as the porphyritic mineral through showing no distinct crystal outline. The plagioclase corresponds in angle of extinction to labradorite, and is arranged in stellate groups forming a somewhat intergrown network of lath-like crystals which enclose smaller masses of pyroxene, together with small particles of magnetite and quartz.

Hornblende Schist and Granite

At thirty-nine miles fifty-six chains is an outcrop of hornblende schist interbedded with masses of pegmatite. The exposure extends for about five chains to the north and strikes N. 60° E., dipping 75° S.E. The rock consists of hornblende and orthoclase and has a decided schistose appearance. The hornblende composes about fifty or sixty per cent. of the rock mass, the balance being made up of pink orthoclase and small traces of epidote. This exposure is considered to be Keewatin.

Just west of forty miles ten chains is a low rounded hill composed mostly of granite and pegmatite, enclosing some masses of hornblende schist. This outcrop extends for about twenty-five chains west of the line and again is exposed on a mountain about a mile to the southwest. Several boulders of mottled melaphyre were observed on this exposure which are of interest as being different from any basic rock found in place on the line. The surface of the outcrop at this point has been polished by glacial action, but no distinct striæ were noticed. The granite in the hand specimen shows quartz, orthoclase, biotite, muscovite and a few garnets. The pegmatite apparently has the same mineral composition. The general direction of the ridge is N. 28° E. The

hornblende schist which is enclosed in the granite usually has a strike of about N. 70° E., and a dip of 54° N.W. On comparing this strike and dip with the strike and dip of the hornblende schist about half a mile south of this point, it will be seen that the rock here has been considerably contorted by the intrusion of the granite. In the hand specimen this schist is very compact, and is apparently composed almost entirely of hornblende. In general appearance it is very similar to the hornblende schist found on the Height of Land portage between the Pic and Making Ground rivers, but is a little coarser.[6] Under the microscope the rock is found to be composed of about sixty per cent. of green hornblende, twenty per cent. orthoclase and ten per cent. quartz, and is apparently the same in composition as the outcrop of schist at the head of the Pic river. This ridge of granite enclosing hornblende schist extends to the northeast as a line of low hills.

At forty miles sixty chains is a similar exposure of coarse granite, which is composed almost entirely of orthoclase and quartz, but also contains a small amount of biotite. Enclosed in the granite are large masses of hornblende schist which in some instances are much curved so that they show no characteristic strike and dip. Cutting both the granite and the hornblende schist are three dikes striking N. 47° W., and standing nearly vertical. One of these dikes has apparently been faulted. The hornblende schist at this point is not quite so dark as that found with the last mentioned outcrop, but is composed of about fifty per cent. hornblende, and the balance orthoclase, with a few grains of quartz. It is, however, much the same type of rock except that it is coarser grained, which fact is probably due to slower crystallization, or to the intrusion of diabase which permitted the crystallization to continue for a longer period of time. The diabase shows in the hand specimen a few lath-like crystals of plagioclase, but none of the dark minerals can be identified. In color it is nearly black and its texture is felsitic. Under the microscope it shows labradorite, augite, pyrite, magnetite and quartz. The labradorite forms the typical network of lath-like crystals characteristic of diabase, and the remaining minerals are grouped in the interstices. Certain portions of the rock have solidified without complete crystallization, and show a ground mass of minute particles whose nature cannot be determined. No glassy particles were noticed, but these masses seem to be made up of microlitic particles of the same minerals as the rest of the rock, which on account of rapid cooling could not take on their characteristic crystal form. The granite at this point is considered to be Laurentian, while the hornblende schist is looked upon as Keewatin.

Exposures of granite with similar inclusions of hornblende gneiss are found on the southeast side of the lake at forty-one miles forty chains. The character of the hornblende schist is identical with the last mentioned outcrop, and the granite contains the same minerals and in some places shows a gneissic structure. Other outcrops of this same rock are found at several places on the line up to the forty-three mile post.

At forty-three miles seven chains is an outcrop of pink granite associated with gneiss. The granite shows in the hand specimen quartz, orthoclase and biotite, and of these three minerals the orthoclase apparently composes about sixty to seventy per cent. of the rock mass. Under the microscope the rock shows, in addition to the minerals mentioned above, plagioclase and chlorite. The rock exhibits a brecciation similar to that noted in the granite at thirty-five miles forty chains. The orthoclase is more or less kaolinized and shows considerable ferric oxide. The pegmatite is the same in composition as the granite. This same body of rock extends west of the line and was found in a valley nearly half a mile west.

About five chains west of forty-three miles thirty chains is a fine grained biotite gneiss in contact with a pink granite which is made up almost entirely of quartz and feldspar, but contains a trace of biotite. In the hand specimen the gneiss is very similar in appearance to the granite found at the first mile post on the line, and shows in the hand specimen the same minerals. Under the microscope the rock is found to be

[6] See page 132.

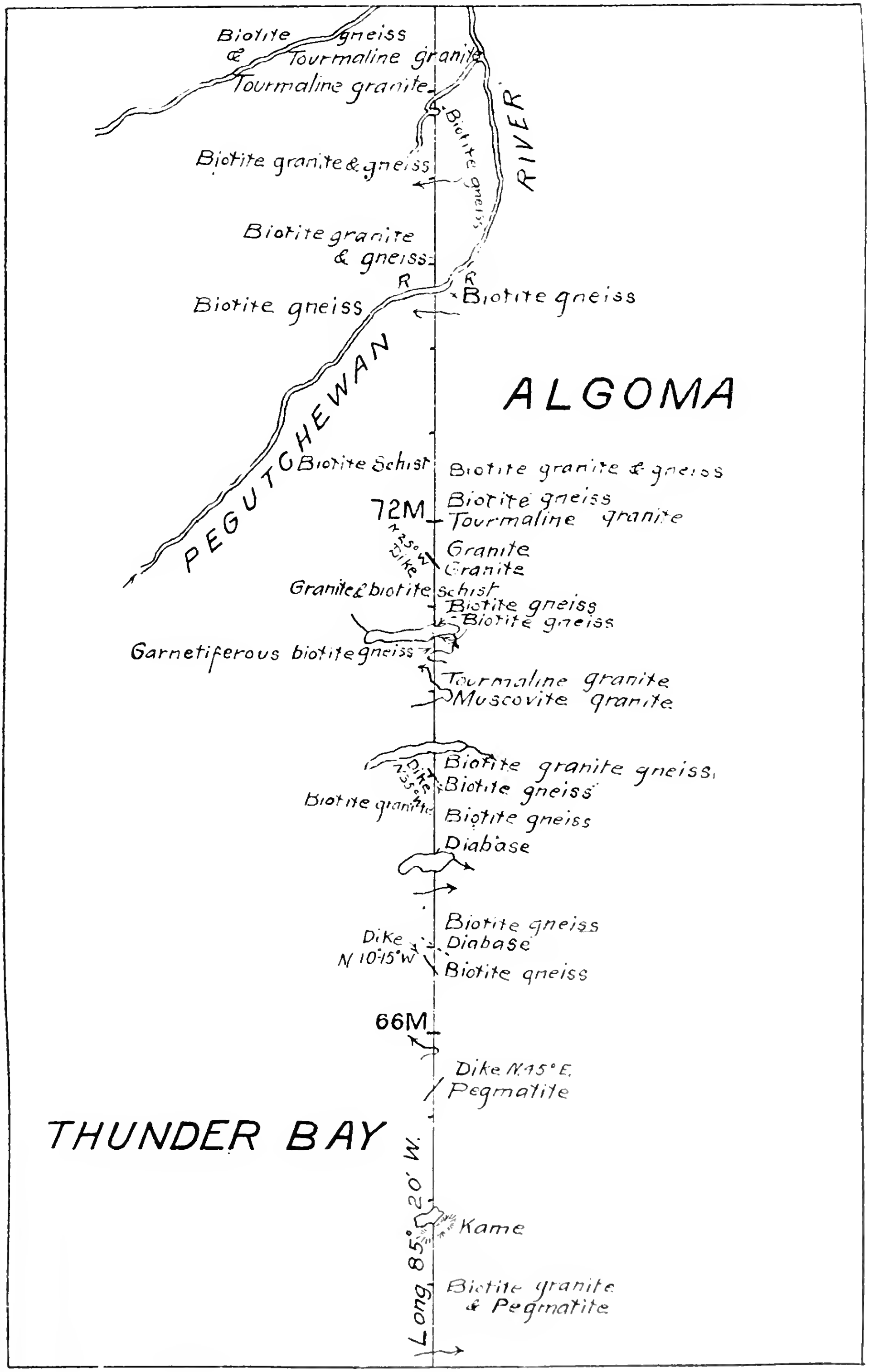

Biotite gneiss
& Tourmaline granite
Tourmaline granite
Biotite gneiss
RIVER
Biotite granite & gneiss
Biotite granite
& gneiss
R
R
Biotite gneiss
Biotite gneiss
PEGUTCHEWAN
ALGOMA
Biotite Schist
Biotite granite & gneiss
Biotite gneiss
72M
Tourmaline granite
Dike
Granite
Granite
Granite & biotite schist
Biotite gneiss
Biotite gneiss
Garnetiferous biotite gneiss
Tourmaline granite
Muscovite granite
Biotite granite gneiss
Dike
Biotite gneiss
Biotite granite
Biotite gneiss
Diabase
Biotite gneiss
Dike
Diabase
N 10-15° W
Biotite gneiss
66M
Dike N. 15° E.
Pegmatite
THUNDER BAY
Long. 85° 20' W.
Kame
Biotite granite
& Pegmatite

Plate V.

composed of quartz, orthoclase, plagioclase and biotite. The orthoclase shows comparatively little kaolinization and only faint traces of included ferric oxide. One small crystal of magnetite was observed in the section. The plagioclase is apparently andesine, and some of it shows zonal extinction from about ten degrees to only one or two degrees, which apparently indicates a gradation from andesine to albite.

Laurentian Gneiss and Keewatin Schist

On the lake about a mile west of this point is a large number of exposures of biotite granite which in some cases exhibits gneissic structure. The lake was followed nearly to the southwest end, and all the outcrops noted to the south and west of this point are Laurentian granites and gneisses. About half a mile west of forty-three miles thirty chains the Laurentian gneiss gives place on the north to a compact hornblende schist having a strike which varies from N. 90° E., to N. 70° E. This rock dips to the south. In color the schist is dark greenish gray and is composed of hornblende and feldspar with traces of orthoclase. The schist is made up of particles of hornblende, which are from a quarter of a millimetre to a millimetre across, but the rock is apparently the same in composition as that found on the Height of Land portage at the head waters of the Pic river, and also about thirty-five miles south of Lake Superior falls on the same river, so that it is classed without hesitation as Keewatin.[7]

About five chains farther north biotite schist is exposed, and in this outcrop it is coarser in texture than most of the schists seen up to this point. The strike and dip of this rock are the same as for the hornblende schist, and apparently it is overlying these schists, so that unless it may be looked upon as an overturned fold or part of an overturned fold it would apparently be difficult to group this schist with the Laurentian. The difficulty in continuing the Laurentian to the north except where the rock is granitic in character is somewhat increased by the fact that much of the schist found in the next ten miles contains garnet, and as these rocks are very similar in appearance to rocks of Grenville age found in the Muskoka District, and as garnetiferous biotite schist on Mackay's lake is referred to the Huronian, it would seem reasonable to class these schists at least as Post-Keewatin. On account of the difficulty, however, of making any correlation between the rocks found on the line and rocks of similar mineral composition found in other places the writer has decided to group these biotite schists, whether containing garnet or not, in the Laurentian.

Going from this lake to the long narrow lake which lies just northeast of it an outcrop of Laurentian granite and pegmatite was found on the east side of the lake about half a mile east of forty-four miles sixty chains. In the hand specimen the granite is almost identical in appearance with Barre granite, quartz, orthoclase and biotite being recognizable. Under the microscope quartz, orthoclase, microcline, plagioclase, titanite, biotite and magnetite are seen. The feldspars grade into one another, and in most cases no characteristic angle of extinction can be obtained, as the crystals seem to be developed with zonal characters. In one case, however, a crystal of orthoclase showed at one end an intergrowth with fine lamellæ of plagioclase which extinguished at eight degrees and is evidently andesine. The titanite shows only one particle which is not well crystallized. The feldspars are kaolinized to some extent and the kaolinization progresses more rapidly along the lines of cleavage. The pegmatite shows only quartz, orthoclase and biotite.

Garnetiferous Schist on Bad River

At forty-four miles forty-one chains is an exposure of pink granite which probably belongs to the same body as the last mentioned, and this gives place at forty-five miles twenty-eight chains to a biotite schist which strikes east and west and dips 60° S. This schist was traced about three miles east of the line and forms the north and south banks of the river for more than two miles, the river's course for this distance being almost

[7] See pp. 132 and 134.

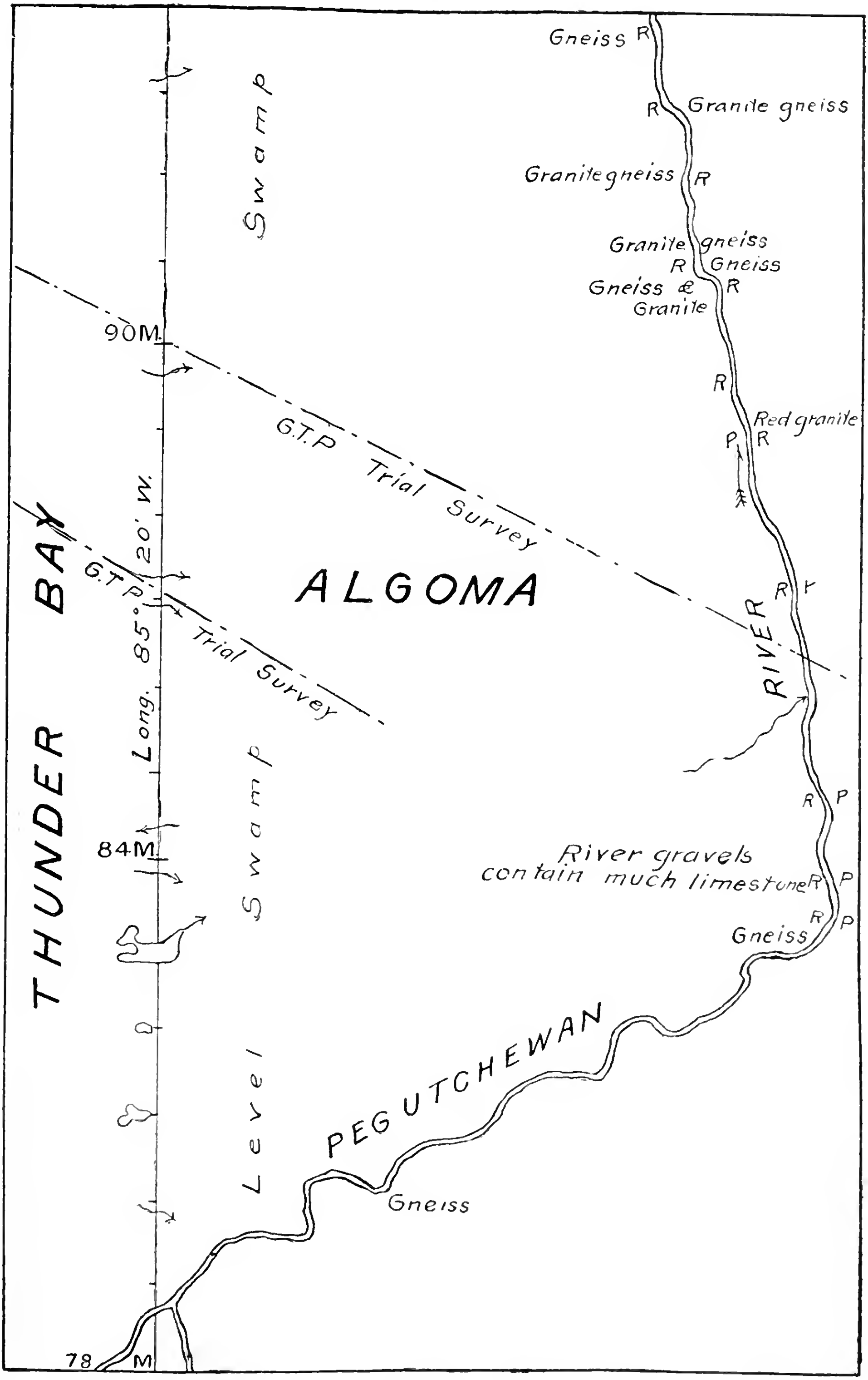

Gneiss R
R Granite gneiss
Granitegneiss R
Granite gneiss
R Gneiss
Gneiss & Granite R
R
Red granite
P R
Swamp
90M.
G.T.P Trial Survey
20' W.
Long. 85°
THUNDER BAY
G.T.P Trial Survey
ALGOMA
RIVER
R
R P
84M.
Swamp
River gravels contain much limestone R P
R P
Gneiss
PEGUTCHEWAN
Level
Gneiss
78 M

Plate VI.

due east. About three miles east of the line the river turns squarely to the north, cutting across this outcrop of schist and forming a rapid about three feet high at this point. This rapid, however, was easily run in a canoe, and it was possible to come up by hard paddling. The river was followed about three miles north of this point, and the surrounding country was gently rolling, but showing at frequent intervals on the west side of the river outcrops of gneiss

In going east from the line the schist was found about ten chains away to be composed of quartz, biotite and orthoclase. In texture it is coarse gneissic. About fifty chains east of the line the texture of the rock is fine gneissic, and in addition to the biotite, quartz and feldspar, minute crystals of pyrite were observed. About a mile and a half east of the line the outcrops consist of alternating bands of biotite schist and granite. In the hand specimen the schist appears fine grained and shows biotite, orthoclase, quartz and garnet. The granitic bands are made up mostly of orthoclase and quartz with small amounts of biotite, and at their contact with the schist show a considerable amount of almandite garnet. At the rapid where the Bad river turns north the schist is composed of quartz, orthoclase and biotite, and in this place no garnet was found. The rock on the line is compact, and although darker than some of the biotite schists which are referred to the Laurentian, it has the same mineral composition, being made up of biotite, quartz, orthoclase and andesine. This band of schist may be looked upon as the southern limit of garnetiferous biotite schist, and although schist which is free from garnet is found at many places within the region where the garnetiferous schists are abundant, it seems to the writer that these schists containing garnet should be separated from the Laurentian, although with the present state of knowledge this cannot yet be done. In some cases it is more than likely that even schists which contain no garnet but are otherwise like the garnetiferous schists should be grouped as post-Keewatin.

An outcrop of biotite schist which in the field appears identical with the rock found at forty-five miles thirty chains occurs on the line at forty-five miles fifty-one chains. Another outcrop consisting of bands of biotite gneiss and granite appears at forty-six miles ten chains and continues about ten chains north. The strike of these rocks is almost east and west. In the hand specimens the gneiss shows quartz. orthoclase and biotite, while the granitic portions are almost entirely feldspar with small amounts of quartz and traces of biotite.

Pegmatite and Biotite Schist

At forty-six miles thirty-two chains coarse pegmatite consisting of quartz, orthoclase, biotite and muscovite is found. The color of the rock is pink or flesh-color. At forty-six miles forty-four chains the rock is granitic in texture and is composed of quartz, orthoclase, biotite, a little muscovite and almandite garnet. This same ridge of rock extends to about forty-six miles fifty-two chains, and there exhibits decided gneissic structure, being composed of quartz, orthoclase and biotite. The strike is N. 70° W., while it dips 60° S.W. About twenty feet west of the line on the north shore of a small lake at forty-six miles sixty chains the summit of a tilted anticlinal fold was noted. Part of the rock had been removed by some agency, leaving a small opening which permitted of measurement of strike and dip. The dip of the north and south sides, a foot or two below the summit of the fold, was found to be the same and measured 70° S.W. The strike at the north side is N. 75° W., while that of the south side is N. 65° W. The summit of the fold is sharply tilted and dips 40° N.W. The rock at this point is biotite gneiss and a coarse biotite granite. The same rock is found on the summit of the mountain at the forty-seven mile post and exhibits a decided gneissic character, showing a strike of N. 70° to 75° W. This rock is not much altered and is composed of quartz, orthoclase, plagioclase and biotite. No thin section was made, but the feldspars appear bright and show little trace of kaolinization. In one specimen small particles of magnetite were observed. This exposure extends about fifteen chains

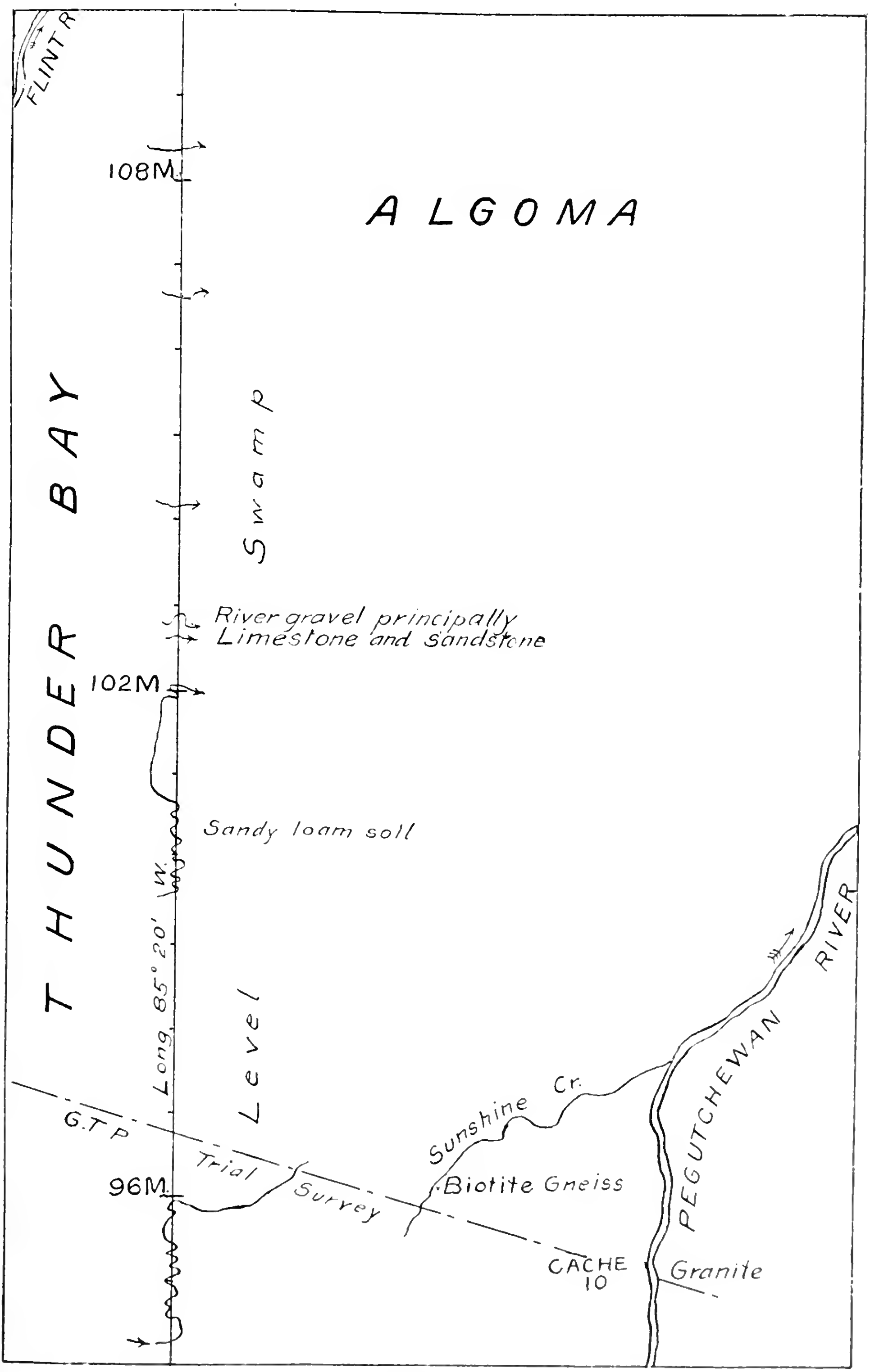

FLINT R.
108M.
ALGOMA
THUNDER BAY
Swamp
River gravel principally
Limestone and sandstone
102M.
Sandy loam soil
Long 85° 20' W.
Level
G.T.P. Trial Survey
96M.
Sunshine Cr.
Biotite Gneiss
PEGUTCHEWAN RIVER
CACHE 10
Granite

Plate VII.

north of the forty-seven mile post and ends in a nearly vertical cliff at the north. The rock was followed about a quarter of a mile to the east, and was there found exposed as a vertical cliff about a hundred and fifty feet high.

At forty-seven miles thirty chains is an outcrop of fine pegmatite or coarse granite, showing crystals of orthoclase and quartz from three-quarters of an inch to an inch across. The outcrop is a small one, and does not extend more than a chain. It apparently was not extended to the east and west, but merely formed a small elevation in the midst of the marsh. Another elevation four chains to the north is made up of biotite gneiss showing quartz, plagioclase and biotite, and having a strike of N. 85° W., dip 80° S. Almandite garnet is present to some extent in certain bands of this rock, but is not abundantly distributed throughout the mass. Biotite gneiss of somewhat granitic texture, but otherwise the same as the last outcrop, is found at forty-seven miles fifty-two chains, and has the same strike and dip as that last mentioned.

At forty-eight miles twenty chains biotite schist containing biotite, quartz and orthoclase, again outcrops, and six chains farther on is a schist which is apparently the same. This latter outcrop strikes N. 85° N.W., and dips 70° N.E. The rock in addition to the minerals found at forty-eight miles twenty chains contains almandite garnet in masses from a quarter of an inch to a half an inch across. Associated with the garnetiferous schist are bands of granitic material composed of quartz, feldspar and biotite. The same rock was again found at forty-eight miles forty-five chains with strike N. 50° W., dip 88° N.E.; also at forty-nine miles one chain, forming a ridge which extended about five chains west of the line and about fifteen chains east of the line. At the latter point the rock was so much contorted that strike and dip could not be taken, but the outcrop extends in a northeast by southwest direction, and ends in a precipitous cliff about fifteen chains east of the line. In texture the rock varies from gneissic to coarse granitic and consists of bands made up of quartz, feldspar and garnet, with or without biotite, alternating with bands composed of quartz, feldspar and biotite. These rocks show a greater percentage of garnet than was observed in any rocks up to this point, and are very similar to the Grenville gneisses.

At forty-nine miles sixty-six chains another outcrop of garnetiferous biotite gneiss forms a hill about five chains wide. The exposure extends about ten chains west of the line and five chains east. The strike of the rock is N. 85° W., and the dip 70° S.W. The rock is distinctly banded, the lighter bands being almost free from biotite and consisting principally of feldspar, quartz and a few scattered garnets, while the darker bands contain possibly twenty per cent. of biotite, an equal amount of garnet and the remainder quartz and orthoclase. Under the microscope the light bands show orthoclase, plagioclase, quartz and biotite. The orthoclase is considerably kaolinized, while the plagioclase has somewhat zonal extinction and probably is partly albite and partly andesine. No garnet was noted in the thin section of the light band, although it is present in crystals an eighth of an inch in diameter in the hand specimen. The dark bands show orthoclase, quartz, andesine, biotite and almandite. The orthoclase is somewhat kaolinized. A few particles of pyrite appear in the dark band, but none were found in the lighter material. This rock continues to fifty miles thirty chains as a series of ridges. At the latter point the banded structure is exceptionally well developed, showing bands from an inch to four inches across with sharp lines of demarcation. Here the strike varies considerably, and the bands are much curved. A dike about two inches across is found a little west of the line at this point, but as the entire length of the dike was only about four feet, and no other exposure could be found in the vicinity, no sample was taken.

At fifty miles fifty chains biotite gneiss outcrops, and again at fifty miles seventy-five chains garnetiferous biotite gneiss is exposed. Again at fifty-one miles twenty-five chains and about five chains west of the line. there is an outcrop of biotite gneiss. In this outcrop no garnet was noticed. About two chains west of the line at fifty-two miles eighteen chains a small outcrop of garnetiferous biotite gneiss appears in the

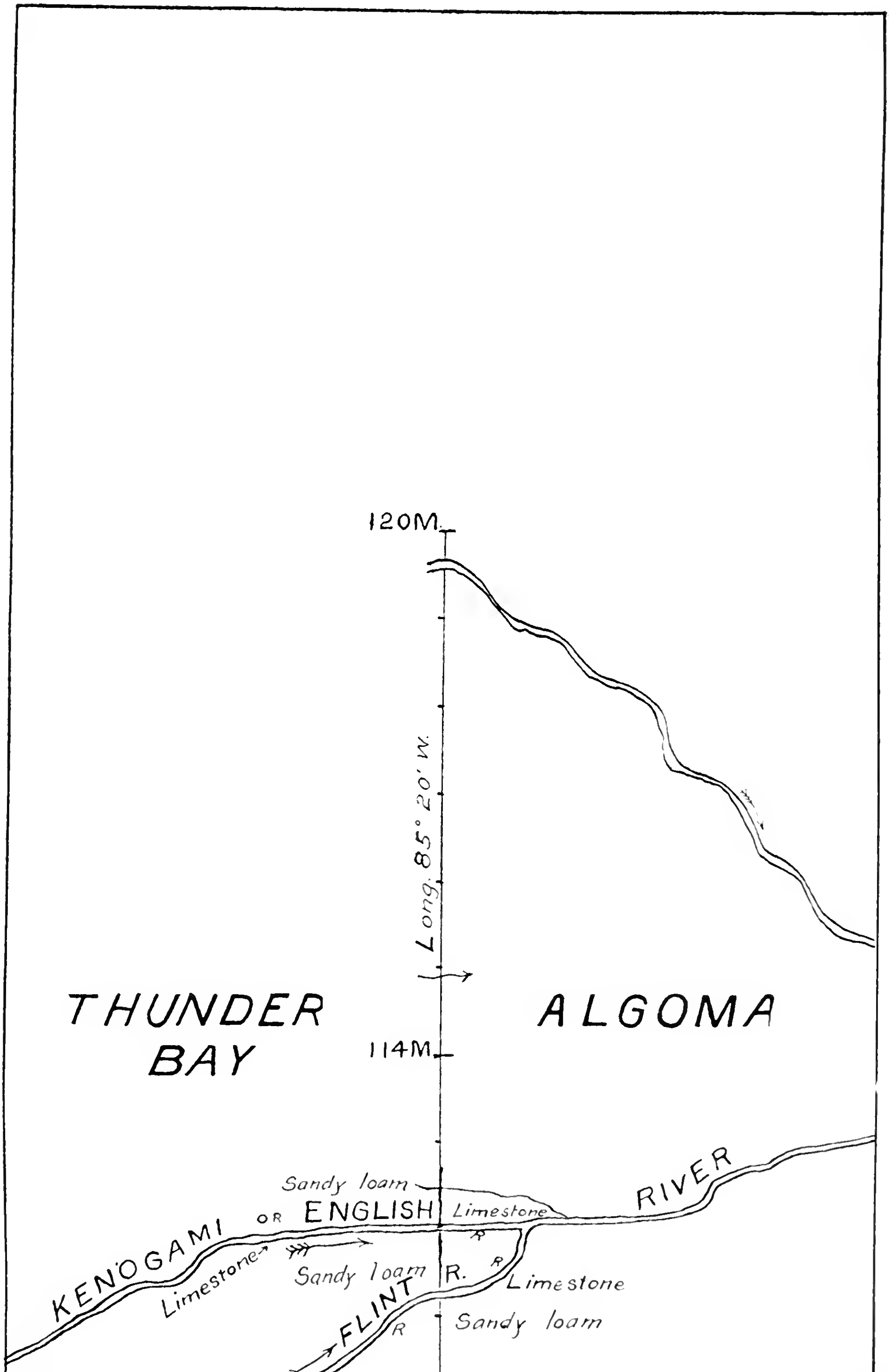

120M.
Long. 85° 20' W.
THUNDER BAY
ALGOMA
114M.
Sandy loam
Limestone
KENOGAMI OR ENGLISH RIVER
Limestone
Sandy loam
R.
FLINT
Limestone
Sandy loam
R
R
R

Plate VIII.

midst of a swamp. The strike is N. 80° E., and the rock is much folded, so that no characteristic dip could be obtained.

An Agricultural Area

At fifty-two miles forty chains a pink granite containing orthoclase and quartz and a very little biotite forms a small knoll in the midst of a spruce swamp and extends six chains to the north. This is the last outcrop of rock to be found up to nearly the fifty-seven mile post. The country between these points consists of sandy knolls and spruce swamps, and just west of fifty-three miles a lake about a mile in diameter gives an opportunity of seeing the general character of this district. From this lake the country rises gradually in all directions, presenting a gentle rolling effect, and inasmuch as the soil is sandy loam it will probably furnish ten or fifteen square miles of good agricultural land.

About a mile west of fifty-six miles sixty chains on the north shore of the lake at that point is an outcrop of garnetiferous biotite gneiss having strike of N. 80° E., dip 80° S.E. This rock is very similar in appearance to the Grenville, but for reasons heretofore stated[8] it is referred to the Laurentian. The rock varies from a coarse granitic to a very fine grained schistose texture. The coarser material shows a somewhat mottled appearance, and is made up of orthoclase, quartz and biotite with occasional inclusions of garnet. The feldspar and quartz are grouped together, and are entirely surrounded by biotite, as if the rock were formed from a sedimentary rock composed of pebbles of argillaceous sandstone embedded in clay, which had been submitted to heat and pressure so as to bring about a re-crystallization of the constituent materials. Garnets up to an inch across are found in this rock. The fine grained schist is similar in composition to the granitic rock, but the minerals are distributed more uniformly, and do not give a mottled appearance.

At fifty-seven miles nineteen chains an outcrop of diabase was found which apparently had a strike of about N. 45° W. The exposure consists of two or three isolated masses about five feet wide and twenty-five feet long. No contact could be found with other rock, as the diabase was bordered on both sides by sandy loam, but as the rock was not particularly rounded it seemed to be a distinct outcrop and not isolated boulders. The rock is considerably weathered and in the hand specimen is dark greenish gray. Megascopically, it exhibits lath-like crystals of plagioclase and pyrite, but the other minerals could not be distinguished. Under the microscope it is found to consist of labradorite, augite, magnetite, pyrite, quartz and secondary calcite and chlorite. The labradorite shows the characteristic network of polysynthetically twinned lath-like crystals. It is considerably decomposed, and shows the formation of much secondary calcite. The other minerals are arranged in the interstices of the labradorite network. The augite is altering to chlorite.

A Lake Shore of Gneiss and Granite

At fifty-eight miles thirty-six chains is a lake which is about three or three and a half miles long and about a mile in greatest width. At the point where the line crosses the lake the width is only about ten chains, and this is about the centre of the lake from east to west. On the south shore at the point where the line crosses the lake is an outcrop of biotite gneiss, and a coarse granite which in the hand specimen shows quartz, orthoclase, muscovite, biotite and apatite. Under the microscope it exhibits the same materials. The shores of the lake show many outcrops of biotite gneiss alternated with coarse granite, and the strike is uniformly east and west with a nearly vertical dip. The country is low and rolling and heavily timbered. On the north shore of the lake about a mile west of the line a dike about a hundred and fifty feet wide is found striking N. 20° E. and having a nearly vertical dip. At the contact of this dike with the adjoining gneiss the rock is very compact, and in the hand

[8] See p. 101.

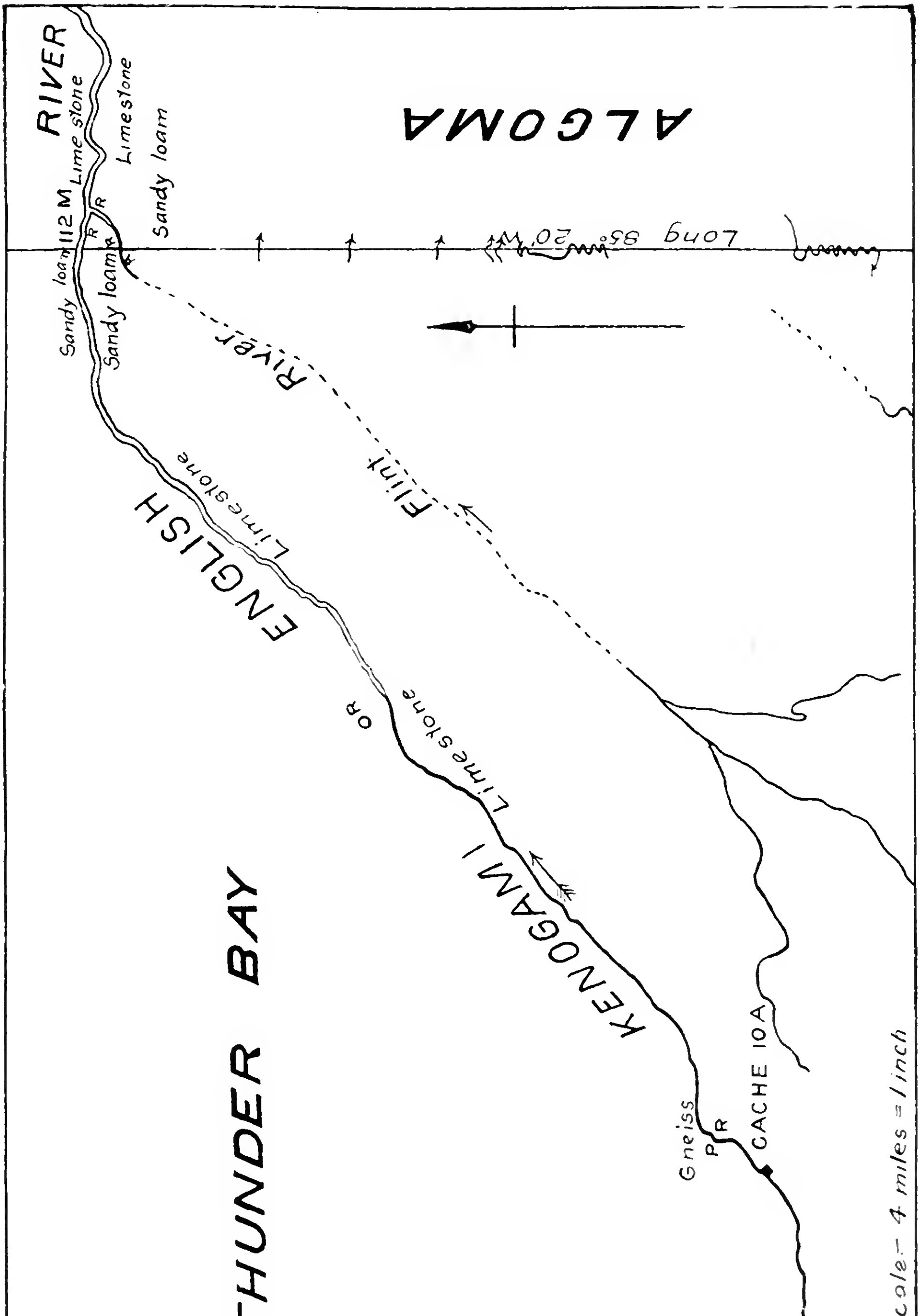

ALGOMA
THUNDER BAY
ENGLISH RIVER
OR
KENOGAMI
Flint River
Limestone
Lime stone
Limestone
Sandy loam
Sandy loam
Sandy loam
112 M
Long 85° 20' W
Limestone
Limestone
Gneiss
P
R
CACHE 10A
Scale – 4 miles = 1 inch

Plate IX.

specimen no minerals can be distinguished. In color it is black, but has a rusty coating due to the oxidation of iron present in the rock. About the middle of the dike the rock is coarsely granitic and exhibits plagioclase, augite and magnetite in the hand specimen, but all gradations in texture between these two extremes can be found. This dike furnishes an exceptionally good example of the effect of slow cooling on the formation of a coarse crystalline rock. Under the microscope the fine grained material near the contact is found to consist of lath-like crystals of labradorite in a dark ground mass of augite, chlorite and magnetite. A section of the coarser material exhibits the same minerals, but on account of the weathered condition of the rock it was not possible to get sections showing the texture.

No outcrop of rock was found between this lake and the lake at sixty miles thirty chains either on the line or in following the creek connecting the two. On the north shore of the latter lake, however, is an isolated rounded outcrop of gneiss which is similar in appearance to that found on the lake at fifty-eight miles thirty-six chains. Outcrops of similar gneiss occur at sixty-one miles twenty chains and sixty-one miles forty chains, and at the latter place it has a strike of N. 80° E., and a dip of 90° Thirty chains farther north this same rock is found.

Granite and Pegmatite at 63 Miles

At sixty-two miles seventy chains granite and pegmatite are exposed and vary in color from pink to gray. Both rocks show in the hand specimen quartz, orthoclase, biotite and muscovite. The exposure exhibits a glacial furrow about eitghteen inches wide and having a direction of N. 45° E. No other rock was observed for more than three miles, but at sixty-three miles sixty chains a sandy ridge rises above the level of the swamp to the south and forms the southern shore of a small lake. The ridge contains pebbles up to an inch in diameter mingled with sand, and has a direction of N. 35° E. Inasmuch as this direction is nearly the same as most of the glacial markings found on the line, the deposit is regarded by the writer as a kame.

A short distance east of the line, at sixty-five miles twenty-eight chains is an exposure of pegmatite composed of quartz, orthoclase, and biotite. The rock is weathered nearly white, and is rounded by glaciation, but shows no distinct glacial scratches. Another outcrop of this same rock is found on the line at sixty-five miles thirty chains. These outcrops are ridges extending N. 35° E., and it is possible that the direction of the ridge is due to glacial action, as it is the same as that noted in the kame at sixty-three miles sixty chains, though it seems more likely that bands of softer material in the rock may have had this direction and thus caused the ice to take the same course.

A dike of diabase showing an outcrop about forty feet long and six feet wide is found at sixty-five miles thirty-five chains. The exact strike and dip could not be obtained on account of the vegetation covering the rock, but the general direction is northeast and southwest. The surface is considerably weathered to a rusty brown, but the less weathered portions are dark greenish brown, and show distinct diabasic texture with its characteristic network of lath-like plagioclase enclosing the dark minerals. Under the microscope the rock is seen to be made up of labradorite, augite, biotite and magnetite. The labradorite is in typical lath-like crystals, polysynthetically twinned, and is partially altered to calcite. The augite is bright and is in the interstices between the crystals of labradorite. The biotite is present in very small amount, and is partially altered to chlorite.

At sixty-six miles fifty-three chains is an outcrop of biotite gneiss with strike N. 45° E., dip 80° S.W. This outcrop consists of alternating bands of dark schist and lighter colored granitic material, and is probably Laurentian.

Diabase at 67 Miles

At sixty-six miles sixty-five chains is a large outcrop of diabase, which extends for several chains each side of the line. The strike is N. 10°-15° W., but the exact direction could not be determined, as the contact with the gneiss could not be seen. In texture

the rock is granitic, and is weathered so that the hand specimen has a reddish brown color. Plagioclase, magnetite, pyrite and augite are visible in the hand specimen. Under the microscope the feldspar is seen to be hypidiomorphic labradorite, forming a network of lath-like crystals enclosing in its interstices augite, biotite, magnetite and a very little quartz. Pyrite was not found in the thin section, although seen in one or two places in the hand specimen.

At sixty-seven miles is a line of boulders or isolated outcrops of diabase, extending in a northwest and southeast direction. No contact was found with other rock and in consequence it cannot be stated positively that there is a dike at this point, but the writer is of the opinion that such is the case. The rock is fine granitic in texture, and shows the same general appearance as the last mentioned except that it is not so brown, and under the microscope the same minerals are found with the same characters, with the exception that quartz was not identified.

At sixty-seven miles seven chains is an exposure of biotite schist of the same character as that noted at sixty-six miles fifty-three chains, and having the same strike.

At sixty-eight miles twenty-five chains is an outcrop of diabase about six feet across, but no extension of the outcrop could be found in the woods near by, so that it is possibly only a large boulder. It has the same characters as the diabase at sixty-seven miles.

Biotite Gneiss and Garnetiferous Granite

Biotite gneiss, both coarse banded and granitic, is found at sixty-eight miles forty chains, sixty-eight miles fifty-five chains, sixty-eight miles seventy chains and sixty-eight miles seventy-five chains. At the last mentioned outcrop the rock is coarsely banded, the dark bands consisting principally of biotite with orthoclase and some quartz, while the light bands are gneissic and are composed mainly of orthoclase and quartz with biotite in small quantities. This rock strikes N. 83° E., and dips 80° S.E. Cutting the gneiss at this point is a dike about one hundred and fifty feet wide, with a strike of N. 35° W., and dip nearly 90°. The rock is dark colored and varies in texture from compact to fine granitic. In the hand specimen the coarser rock shows plagioclase, augite and magnetite. Microscopically, it is found to be composed of an interlaced network of hypidiomorphic labradorite polysynthetically twinned, while in the interstices are augite, biotite and magnetite. The compact material when examined under the microscope is seen to be microporphyritic, with phenocrysts of lath-like labradorite and augite. The ground mass is dark, and is composed of biotite, magnetite and a large mass of unindividualized material which appears somewhat chloritic.

At sixty-nine miles fifteen chains biotite granite gneiss is again found, and the same rock is again seen fifteen chains further north on the south shore of a small lake. These exposures have a coarse banded appearance, and are probably Laurentian. At sixty-nine miles seventy-five chains is a coarse granite made up of orthoclase, quartz, muscovite and magnetite. This outcrop extends N. 80° E., but does not exhibit gneissic texture. At seventy miles ten chains is a granite showing in the hand specimen quartz, orthoclase, plagioclase, biotite and occasional specimens of tourmaline. The surface of the exposure is rounded and polished by glacial action, but no striæ were observed. The outcrop is a large one and extends for about fifteen chains east of the line. Most of the rock is rather coarse grained, many of the crystals being nearly half an inch across. Along with this material is a fine grained granite which shows under the microscope all the minerals found in the coarser material, with the exception of tourmaline.

At seventy miles fifty chains is a gneissic outcrop of garnetiferous granite and a biotite schist. The outcrop extends about eight chains north on the line and about fifteen chains east, while the extension to the west is about three or four chains. This rock strikes N. 80° E., and the dip is 75° N.W. The surface of the rock is rounded, apparently by glacial action, and although the surface is much weathered, yet it is not broken up to any extent, so that considerable difficulty was experienced in getting

samples. The granitic bands are light colored, being composed of quartz, white feldspar, a small amount of biotite, and a few small purple garnets which show no trace of decomposition and are apparently almandite. No thin section of this rock was made, and it is uncertain whether the feldspar is white orthoclase or albite. The schistose bands are composed of quartz, orthoclase, biotite and chlorite.

At seventy miles sixty chains is a lake which shows exposures of biotite gneiss on the north and south shores. The direction of the lake is N. 70° E., and at the east end is a large flat of two or three hundred acres overgrown with swamp grass. The rock at this lake is biotite gneiss, and its strike is N. 80° E.

At seventy miles seventy chains is a gray biotite gneiss varying from fine schist to rock which is almost granitic in texture. The granitic bands are gray and show in the hand specimen biotite, feldspar and quartz. Under the microscope the rock is found to consist of quartz, orthoclase, microcline, plagioclase which approaches andesine in angle, biotite and muscovite. This outcrop strikes nearly east and west, and continues on the line nearly to the seventy-first mile post.

Exposures of Granite

At seventy-one miles ten chains is a ridge of granite which varies in texture from a coarse pegmatite to a fine granite. It is bordered on the north by biotite schist and the outcrop extends N. 85° E., for a distance of more than twenty chains east of the line In places the schist is found included in the granite. The granite and pegmatite show in the hand specimen orthoclase, quartz and biotite. Under the microscope the biotite is seen to be almost entirely unaltered. The remaining minerals are shown to be quartz, orthoclase, microcline, plagioclase which shows zonal extinction, and a little muscovite. No sample of the schist was taken, but it is dark and consists of more than fifty per cent. biotite, with the remainder orthoclase and quartz. This exposure is so polished by glacial action, that in many places it is extremely difficult to maintain a foothold, but no glacial striæ were observed.

At seventy-one miles thirty chains an exposure of granite, like the last mentioned, is found on the west side of the line, and although the ground is high at the east of the line the rock was not found outcropping on that side.

At seventy-one miles thirty-five chains a dike cuts the granite, and has a strike of N. 25° W. The width of this dike is from one hundred and twenty-five to one hundred and fifty feet. In the hand specimen the rock is mottled, particularly in the weathered portions where the feldspar shows a brownish tinge. In the unweathered portions the rock is dark greenish gray, and exhibits lath-like crystals of plagioclase, some magnetite and augite. Under the microscope the rock is found to be made up of an interlaced network of hypidiomorphic labradorite, with augite and magnetite filling the interstices. A small amount of biotite altering to chlorite is observed. The augite is fairly fresh, but around the edges is altering to chlorite.

At seventy-one miles thirty-seven chains granite like that last mentioned again appeared, the outcrop extending about fifteen chains north and for some distance each side of the line. The rock, however, is not all exposed, as there is considerable timber growing upon it, and much of it is covered by moss and soil.

At seventy-two miles is an exposure of granite about one chain wide and extending about five chains east and west of the line. The rock varies in texture from coarse to fine granitic, and in the hand specimen shows quartz, orthoclase, biotite and black tourmaline. Under the microscope the rock is seen to be composed of quartz, microcline, plagioclase with zonal extinction, biotite and muscovite. The feldspars are altered in a large measure to kaolin, and apparently the kaolinized material is due to the decomposition of orthoclase, although no characteristic orthoclase is identified in the slide. The other feldspars are bright, and show almost no trace of decomposition. Although the hand specimen shows good crystals of tourmaline, none of this mineral was found in the thin section.

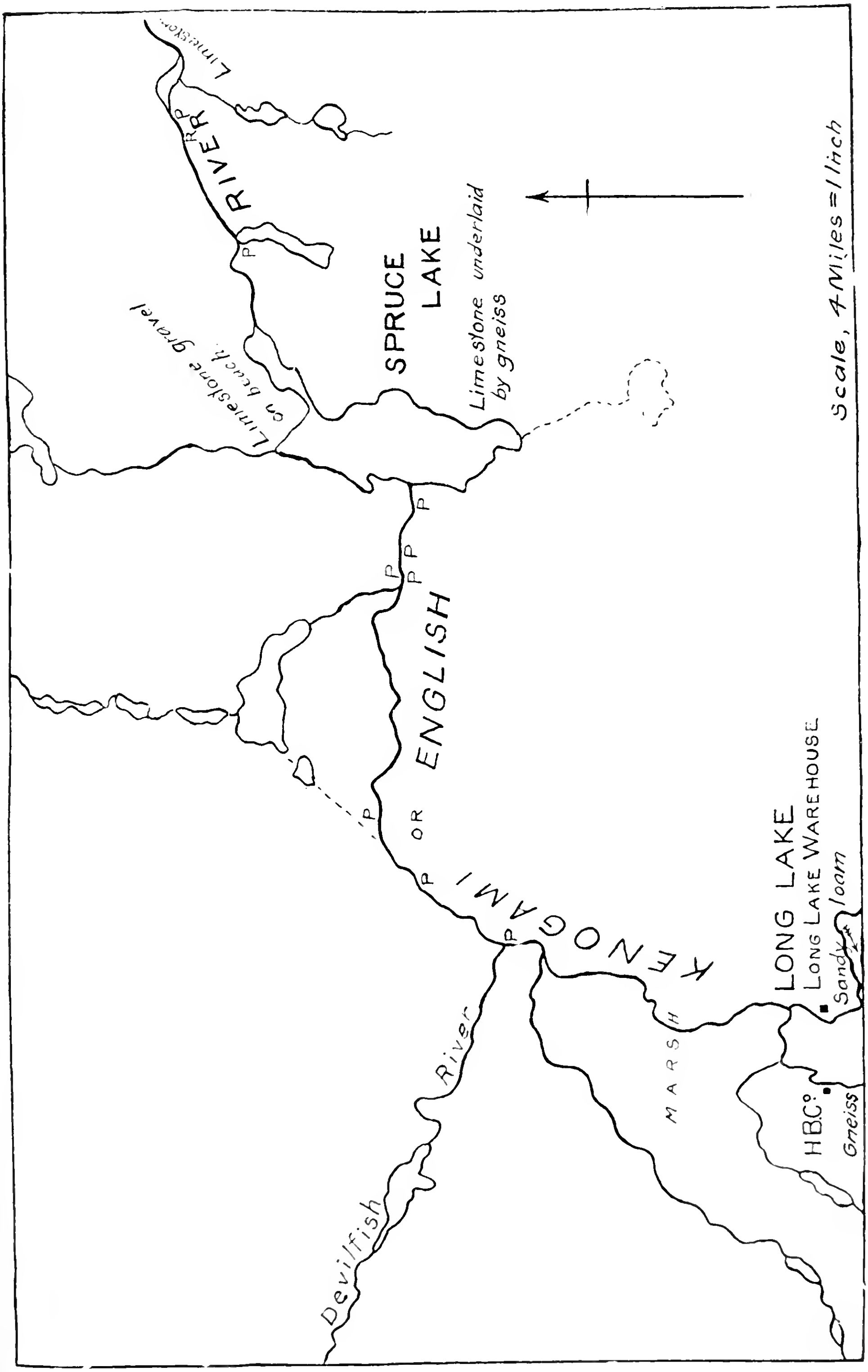

Limestone
RIVER
SPRUCE
LAKE
Limestone underlaid
by gneiss
Limestone gravel
on beach
ENGLISH
OR
KENOGAMI
Scale, 4 Miles = 1 Inch
LONG LAKE
LONG LAKE WAREHOUSE
Sandy loam
MARSH
H.B.C°.
Gneiss
Devilfish
River

Plate X.

At seventy-two miles ten chains is an exposure of biotite schist banded with granite and having a strike nearly east and west.

Extending from seventy-two miles forty chains to seventy-two miles fifty chains is a granite containing inclusions of biotite gneiss. This granite varies in texture from a fairly coarse pegmatite to fine granite, and shows in the hand specimen orthoclase, quartz, muscovite and tourmaline. Under the microscope, the rock is found to consist of quartz, orthoclase, plagioclase approaching albite in angle, and blue tourmaline. No muscovite was found in the thin section, and it is abundant only in the pegmatitic portions of the rock.

At seventy-two miles fifty-six chains the granite gives place to biotite schist with strike N. 70° W., dip 78° S.W. No outcrop of rock was found between this point and the south branch of the Pegutchewan river, but about twenty chains east of the line at seventy-four miles sixty chains is a ridge of granitic rock about two hundred feet high, which extends in a northeast and southwest direction. At seventy-five miles three chains is an exposure of granite and gneiss of similar character. Both these rocks are banded and are made up of orthoclase, quartz and biotite.

At seventy-six miles thirteen chains is an outcrop of granite and biotite schist having the same character as the last.

At seventy-six miles seventy chains is a ridge of granite and gneiss two chains east of the line. This ridge is about a hundred feet high and extends nearly north and south. The strike of the rock, as nearly as could be ascertained in view of its contorted nature, is about N. 60° W. The rock varies in texture from coarse to fine granitic. The coarser bands are made up almost entirely of orthoclase and quartz, with small amounts of biotite. The finer grained material contains the same minerals, but the biotite comprises about thirty per cent. of the rock.

At seventy-seven miles a granite which is apparently the same in composition as that seen at seventy-two miles is found. With this granite is gneiss with strike N. 75° W., and dip 85° N.E. Twenty-three chains farther north is another outcrop of similar material with strike N. 50° W., dip 80° N.E. The rock at this place consists of bands of pegmatite and biotite gneiss. The gneiss is composed of biotite, quartz and orthoclase, while the pegmatite contains in addition to these constituents black tourmaline. This is the last rock outcrop found on the line south of the English river.

Down the Pegutchewan River

At seventy-eight miles fifty-four chains the line crosses the north branch of the Pegutchewan river, and from that point to the English river the country is nearly level and is covered by a dense spruce swamp. On reaching the Pegutchewan river it was found that our supplies would not be sufficient to take us more than twenty miles, and in consequence the writer in company with Mr. Mitchell and Mr. Wm. Gregory started down the Pegutchewan river with provisions for a week, in search of supplies. On account of the necessity of travelling rapidly it was impossible to make any study of rocks found. At the point where the line crosses the river the current is swift and the stream very deep.

For a distance of about twenty miles the stream has a meandering course, and flows through a country which is approximately level. The banks of the river are clay covered with sandy loam and sand, and this country will when cleared make an excellent agricultural region. The shores are burned to some extent and on these old burns are groves of Banksian pine, balm of Gilead, birch and poplar. These burned patches seldom reach to the river's bank, but a fringe of large trees is found nearly the whole distance down the river. About four or five miles east of the line and again about ten miles east of the line, outcrops of gneiss were observed, the first being south of the river, and the latter near the point where the river turns north. Soon after the river turns north there are two rapids with a total fall of about twenty-five feet, which will furnish good water-power. At the foot of the lower rapids a large number of

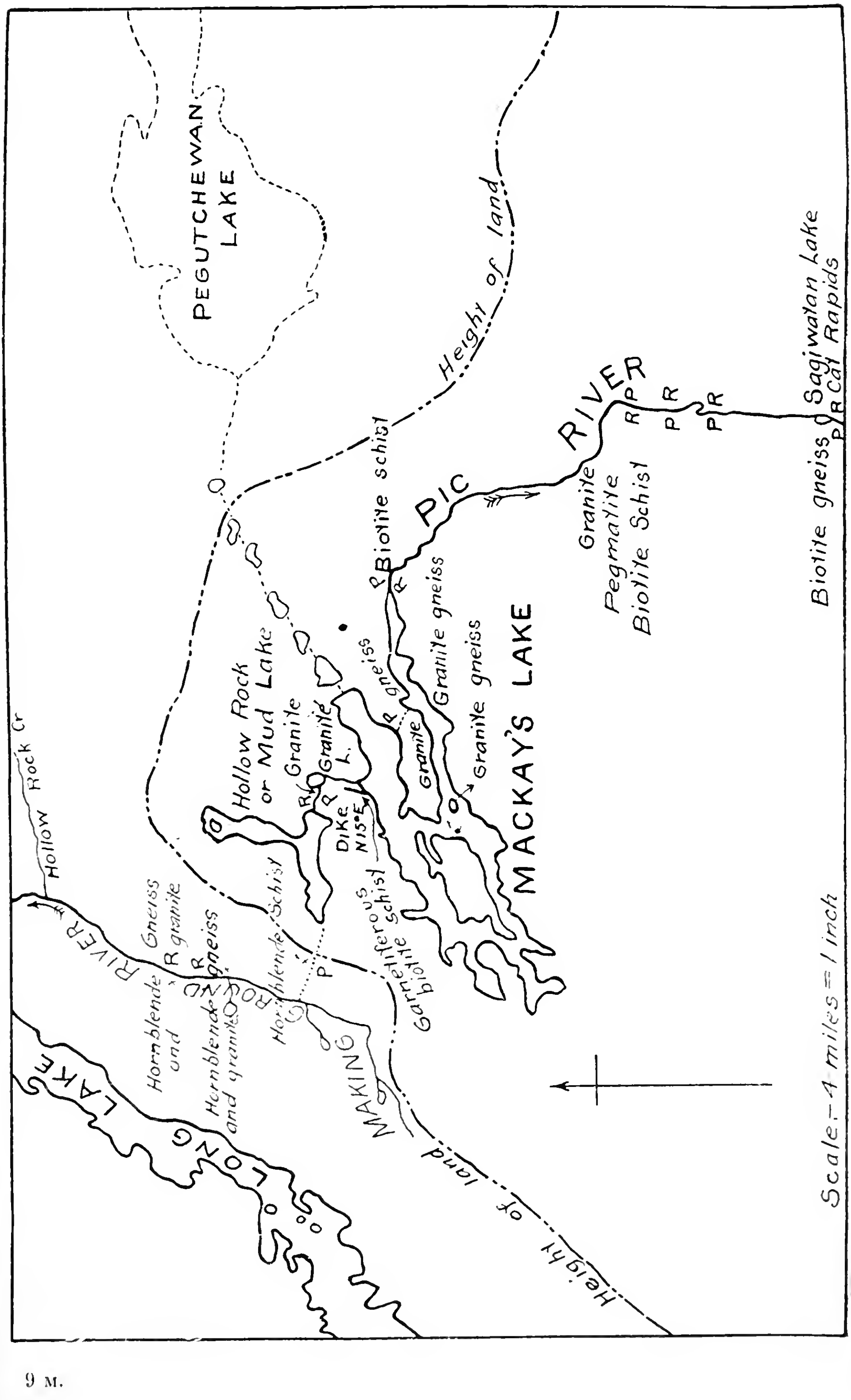

PEGUTCHEWAN LAKE
Height of land
Biotite schist
PIC RIVER
Sagiwatan Lake
Cat Rapids
Biotite gneiss
Granite
Pegmatite
Biotite Schist
MACKAY'S LAKE
Granite gneiss
Granite gneiss
Granite gneiss
Granite
Hollow Rock or Mud Lake
Granite
Granite L.
DIKE N15°E
Garnetiferous biotite schist
Hornblende Schist
Hollow Rock Cr
ROUND RIVER
Gneiss R granite
Hornblende and granite
Hornblende and granite
MAKING
LONG LAKE
Height of land
Scale.—4 miles = 1 inch

Plate XI.

limestone pebbles of Lower Devonian age were observed, and rocks of similar character were frequently noticed in the river gravels from this point north; in many cases these rocks comprised more than half the river gravel, and although no outcrop of this rock was found in this vicinity, it is the opinion of the writer that the whole flat between the Pegutchewan river and the English river was at one time, if not at the present, underlain with this limestone. The river from this point to the cache of the Transcontinental Railway Company is shallow, and has many rapids, and because of its character it gets the Indian name Pegutchewan, or Shallow Current river. About six miles east of the ninety-two mile post is a rapid with a fall of about twenty-five to thirty feet. On the west bank at this point is an exposure of gneiss and granite with inclusions of gneiss. About half a mile farther north is another outcrop of gneiss on the east bank. Another rapid is found about a quarter of a mile to the north of this last outcrop, and at the foot of the rapid is an exposure of granite gneiss which outcrops on both sides of the river. Another rapid was found about half a mile farther north with an outcrop of granite gneiss at the foot, and still another outcrop of gneiss was noted on the east shore after paddling for about ten minutes. Two more shallow rapids which were run with the canoe were just below this last outcrop, and finally at about six miles east from the ninety-five mile post we came to cache 10 of the Transcontinental Railway Company. Just opposite the cache on the east side of the river is an outcrop of granite nearly a hundred feet high and with a face on the river about two hundred feet broad. The forest here has recently been burned, and in consequence the rock shows a rusty color, due to a change in the condition of the iron present. In texture it is fine granitic, and shows in the hand specimen quartz, orthoclase, a few striated crystals of plagioclase, and biotite. Microscopically, the rock is found to consist of biotite, quartz with inclusions of zircon, orthoclase altering to kaolin, microcline, and plagioclase which approaches andesine in angle.

In coming down the river although there is considerable fall it was noted that the general level of the country away from the river bank remained about the same.

About three miles west of cache 10 is an outcrop of biotite gneiss, apparently of Laurentian age. From this point to the Flint river no rock of any sort was seen. In a few places the soil was examined and found to be a sandy loam. On the banks of streams this loam is seen to be underlain with a yellowish clay. On the small river which crosses the line at about one hundred and three miles, the river gravels consist principally of limestone, sandstone and diabase, although scattering pebbles of granite are seen. The banks consist principally of yellow clay which is covered with sandy loam.

Limestone on Flint and English Rivers

On going down the Flint river a buff limestone was observed in the bed of the stream, but no outcrop was seen which was accessible. This limestone was found in place, however, on the English river for about sixteen miles above its junction with the Flint river, and samples were taken in two places. These samples contained three fossils which have been identified as *Atrypa reticularis*, *Stropheodonta, cf. pattersoni*, and *Rhipidomella sp.* These in connection with those listed by Mr. Neelands[9] would probably determine this limestone as Lower Devonian.

The crystalline rocks of the English river have been described by Mr. Neelands, so that the writer made no attempt to study them on the trip up the river. The occurrence of limestone was noted about half way between cache 10A of the Transcontinental railway and Spruce lake, and the shores of the lake showed several gravelly beaches containing large quantities of limestone pebbles.

Making Ground and Pic Rivers

On leaving Long lake we went up the Making Ground river for about twelve miles to the Height of Land portage. At the foot of the first rapids on this river is a compact hornblende gneiss associated with granite, and about two miles farther up is another

[9] Rep. Survey and Exploration Northern Ontario, 1901, p. 151.

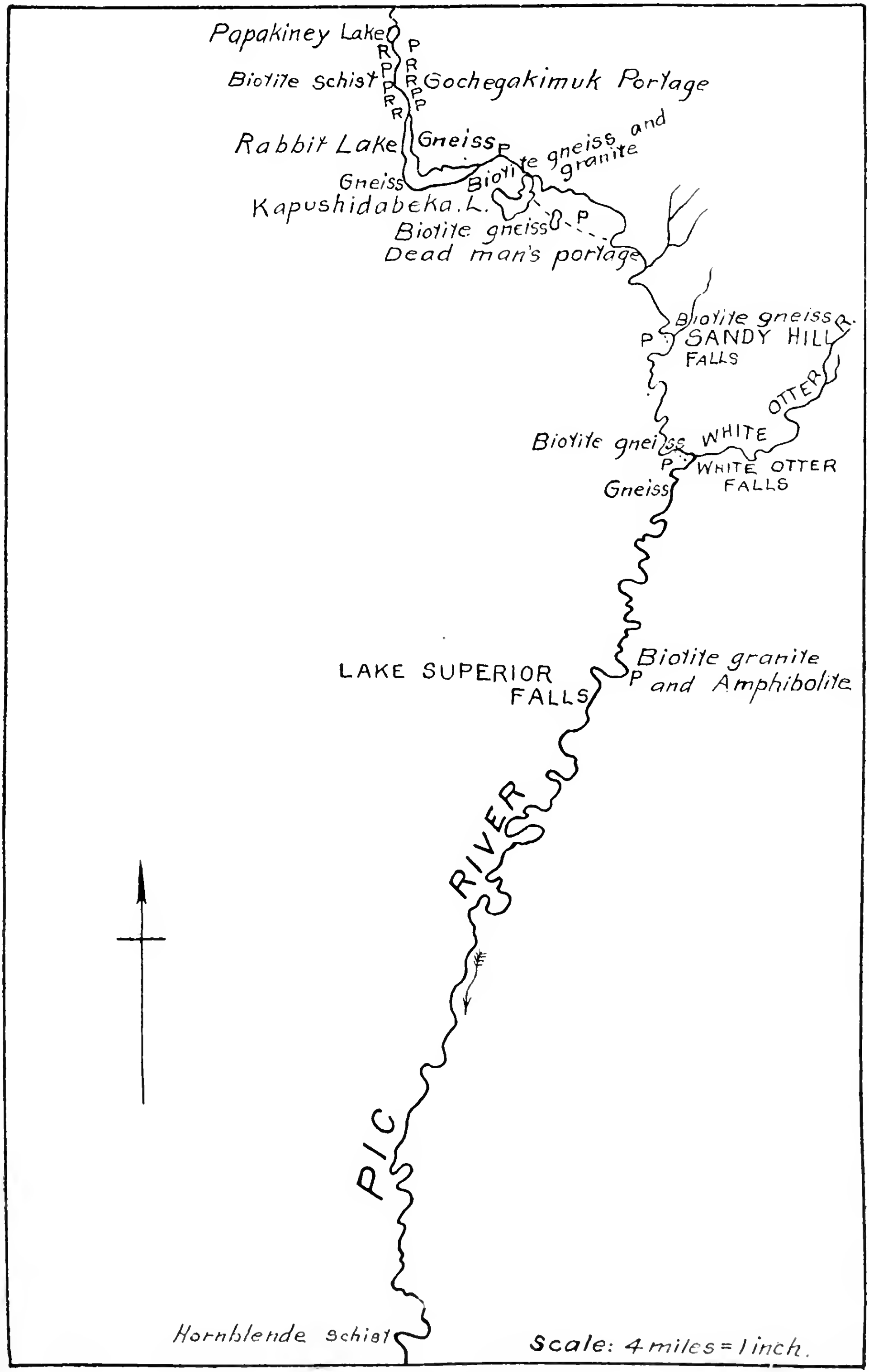

Papakiney Lake
Biotite schist
Gochegakimuk Portage
Rabbit Lake
Gneiss
Biotite gneiss and granite
Gneiss
Kapushidabeka. L.
Biotite gneiss
Dead man's portage
Biotite gneiss
SANDY HILL FALLS
R.
OTTER
WHITE
Biotite gneiss
WHITE OTTER FALLS
Gneiss
Biotite granite and Amphibolite
LAKE SUPERIOR FALLS
RIVER
PIC
Hornblende schist
Scale: 4 miles = 1 inch.

Plate XII.

exposure of the same material, which in the hand specimen shows the dark bands to be made up principally of hornblende with some chlorite, while the lighter streaks are composed of quartz and orthoclase. The strike of this last exposure is east and west, the dip 53° S. Between the Making Ground river and Mud lake, at the head of the Pic river, is a portage one and a half miles long (pedometer measurement).

At the west end of Mud lake is an outcrop of compact hornblende schist striking east and west and dipping 68° N. In the hand specimen the minerals composing this schist cannot be determined, but under the microscope it is found to consist of minute particles of green hornblende with a very small amount of quartz and feldspar. This rock is probably Keewatin in age. On the outlet of Mud lake is a coarse granite composed of quartz, orthoclase and hornblende, with a few particles of magnetite. The rock varies from coarse granitic to pegmatitic in structure.

On Mackay's lake, about a mile south of the inlet, is a dark schist which in the hand specimen shows no minerals which can be identified, except a few pieces of quartz. Under the microscope it is seen to consist of quartz and orthoclase, the grains of which minerals are surrounded or nearly surrounded by small flakes of biotite. Two or three garnets are to be seen in this material, and as heretofore this rock has been classed as Huronian it may be looked upon, possibly, as a phase of the garnetiferous biotite gneisses found upon the line at about fifty miles north of White river. This, however, cannot be stated positively until work has been done on the extension of the outcrops. Cutting this schist is a dike of diabase of fine granitic texture, which in the hand specimen shows lathlike plagioclase and magnetite. Under the microscope it is found to consist of labradorite, augite, magnetite and some secondary calcite and chlorite. The texture is that of a typical diabase, consisting of an interlaced network of lath-like crystals of labradorite, while in the interstices are grouped the augite and magnetite.

Water Powers and Rock Formations on the Pic

Near the east end of Mackay's lake the rock consists of granite and biotite gneiss, probably of Laurentian age. A sample of gneiss taken about a mile and a half from the outlet, on the south shore of the lake, is composed of biotite, quartz and orthoclase. Near the first rapids below Mackay's lake is a schist not distinguishable from the last mentioned, which strikes N. 65° E., and dips 80° N. Four hours' run below the first rapids is an exposure of granite on the west bank of the river. On the weathered surface the feldspars are yellow, due to iron rust, and in fact the entire surface is apparently coated with a deposit of limonite. On the fresh fracture the rock is seen to be composed of quartz, biotite and white feldspar, which shows striations on the cleavage faces and is probably albite.

After another hour's run we came to the second rapids where there is a large exposure of pegmatite enclosing biotite schist. The fall of this rapid is not over ten feet, but it furnishes a good location for a dam as the storage above is large.

At the outlet of Sagiwatan lake is an exposure of biotite gneiss striking N. 50° E., and having a nearly vertical dip. The rock is exposed on both sides of the river, and between the exposures is a swift rapid known as Cat rapid. The rock varies in texture from coarse granitic to gneissic, and is composed of quartz, white feldspar and biotite. No striations were observed upon the cleavage faces of the feldspar, and it probably is orthoclase altering to kaolin.

At Gochegakimuk portage is a good water power. The rapid at this point has a fall of about fifteen feet. At this point there is a compact biotite schist composed of quartz, orthoclase, and a small amount of biotite.

At the upper end of Rabbit lake a coarse pegmatite outcrops just below Sagebouti portage, but about a quarter of a mile down the lake on the east side the rock becomes granitic in texture and is composed of quartz, orthoclase and biotite which are visible in the hand specimen. Under the microscope these same minerals appear and in addition microcline, and microperthite. The orthoclase is kaolinized to some extent.

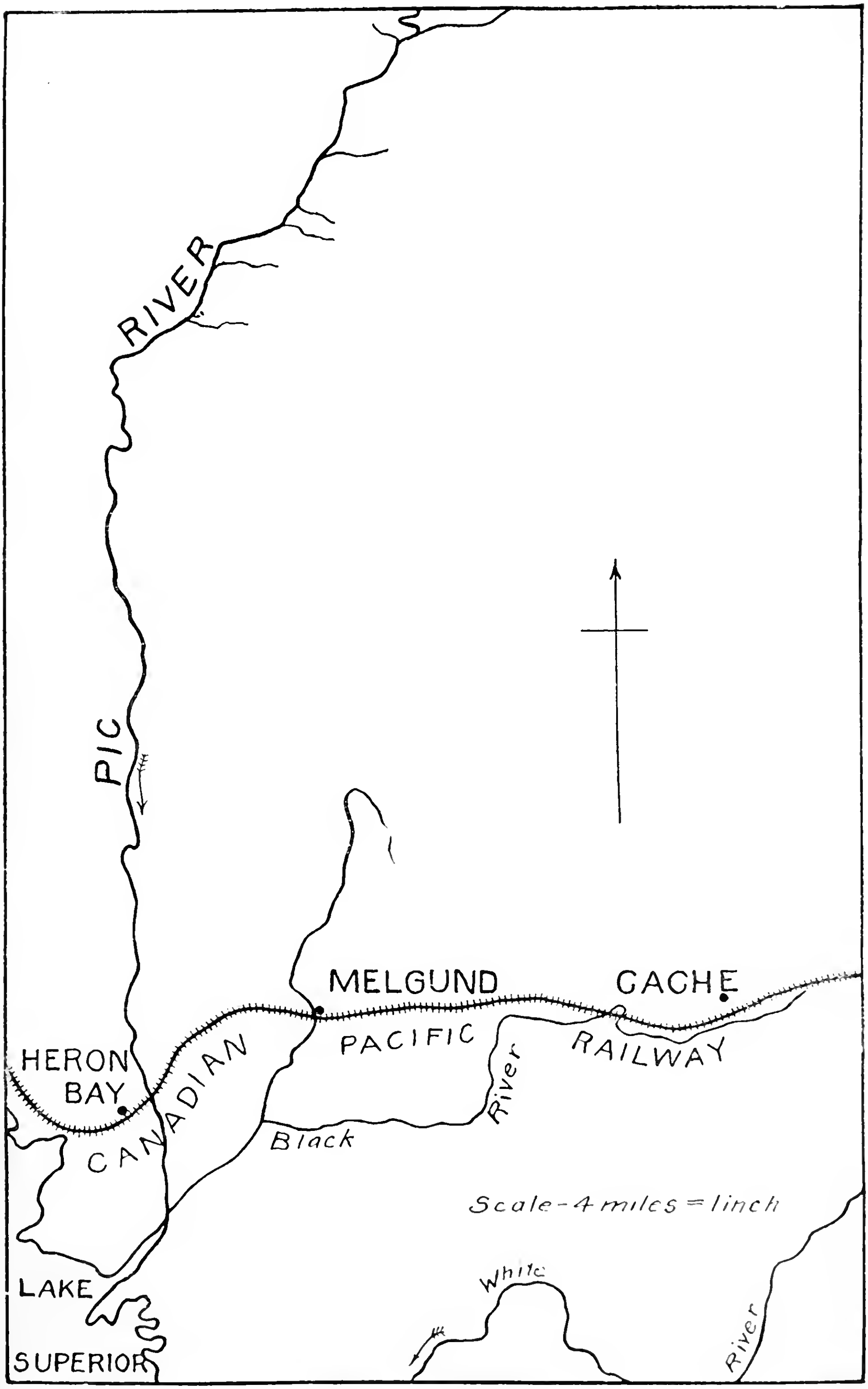

PIC RIVER
MELGUND
CACHE
HERON BAY
CANADIAN PACIFIC RAILWAY
Black River
Scale-4 miles = 1 inch
White River
LAKE SUPERIOR

Plate XIII.

Below Rabbit lake is Split Rock rapid, which has a fall of about twelve feet and would furnish good water-power. At this point biotite gneiss and granite are found which strike nearly east and west and have an almost vertical dip.

Below this rapid one enters directly into Kapushidabeka lake, and from this lake the route leads across Dead Man's portage, which has a total length of about two miles, but is broken by a lake about a quarter of a mile long about a quarter of the way across. This portage is made to avoid a long and dangerous rapid. On the small lake on Dead Man's portage biotite gneiss is to be seen, but most of the portage is on clay loam.

At Sandy Hill falls the rock is a much contorted biotite gneiss showing quartz, feldspar and biotite in the hand specimen. Under the microscope this rock is found to consist of quartz, orthoclase, microcline, plagioclase with zonal extinction, and biotite. The orthoclase and microcline are altering to kaolin, but the plagioclase appears quite bright. Similar granite and gneiss were to be seen at White Otter fall. At this point good water-power can be developed, though there is not much storage above the fall.

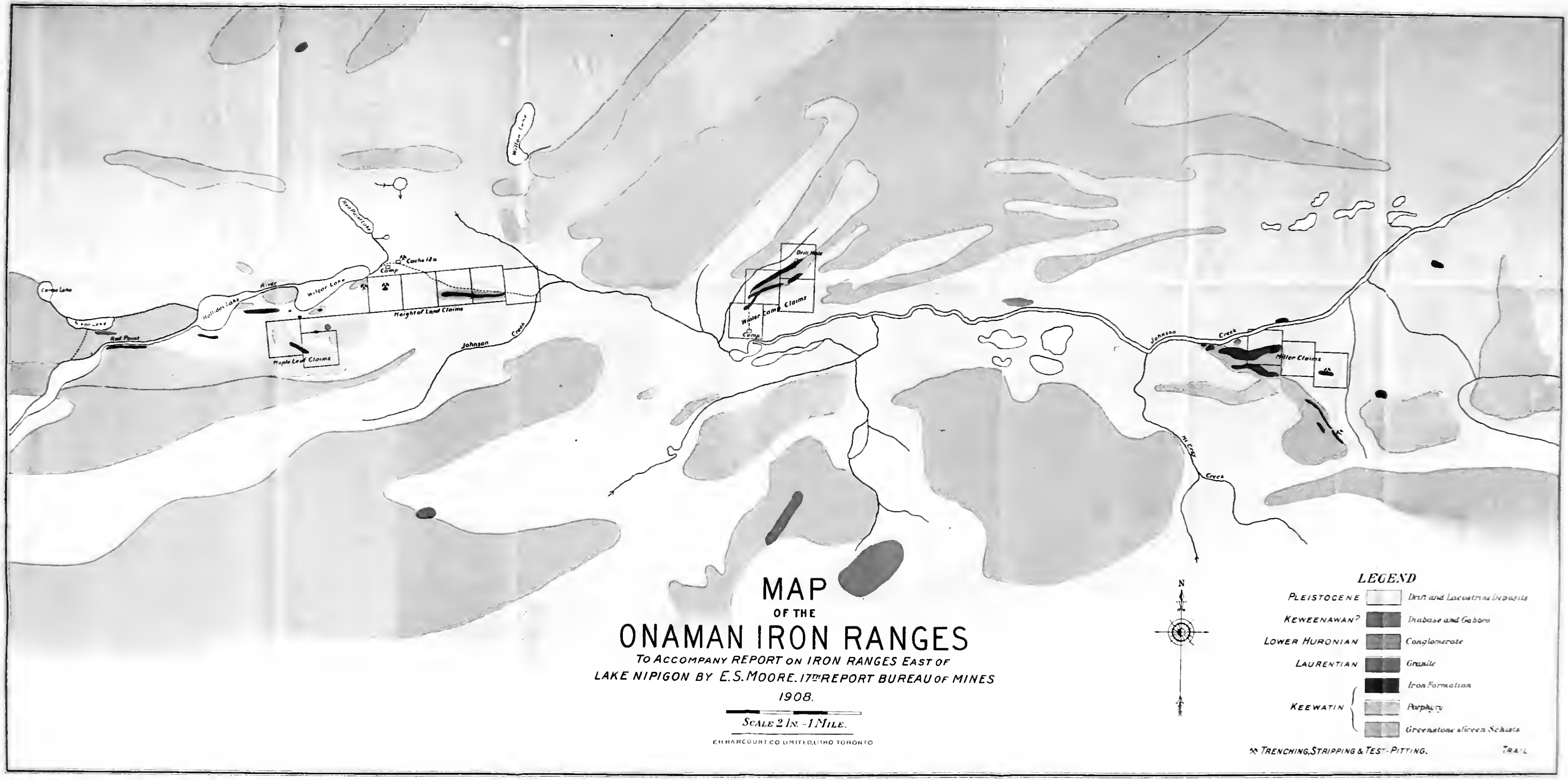
At the top of Lake Superior falls the rock is hornblendic and consists of alternating bands of granite containing biotite, quartz and feldspar, and basic bands consisting apparently almost entirely of hornblende. The rock is much contorted, and has a general strike of N 50° E., and dip 75° N., though there is considerable variation, due to flow structure and folding. Under the microscope the light bands are found to consist of quartz, orthoclase, microcline, plagioclase and biotite. Kaolinization has not progressed very far in this rock. The plagioclase has an extinction angle of about 4 or 5 degrees and is probably albite. Under the microscope the dark bands are shown to consist almost entirely of hornblende with small amounts of orthoclase and albite. The rock is apparently amphibolite which may have its origin in the same materials as go to make up the Keewatin schists in this part of the country.

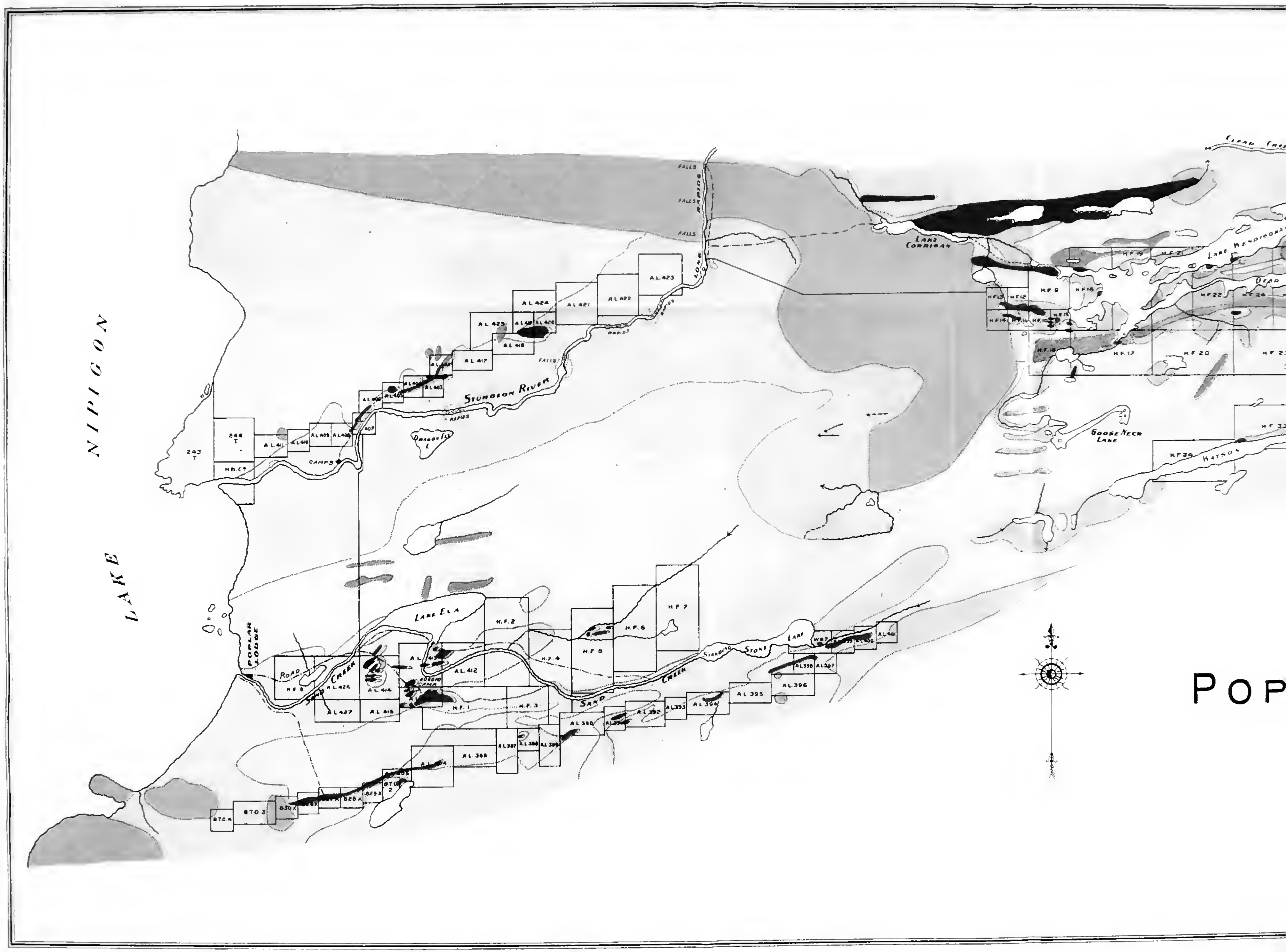
Seven and a half hours or about thirty-five miles below Lake Superior falls an outcrop of compact hornblende schist was found on the river bank. In the hand specimen it is dark green to black in color, and is so compact that none of the component minerals can be identified. Under the microscope, however, it is seen to be composed of hornblende with fine particles, which may be quartz, or more probably quartz and orthoclase, but which are too small to be identified even with the microscope. The thin section shows an excellent example of micro-folding, and the hornblende crystals are arranged parallel to the side of the folds in such a way as to cause all the crystals on the same side of the fold to extinguish at the same angle. This rock is undoubtedly Keewatin in age.

No other outcrops of rock were examined below this point, although the mountains in some cases showed rock near their summits, most of which were apparently of Laurentian age.

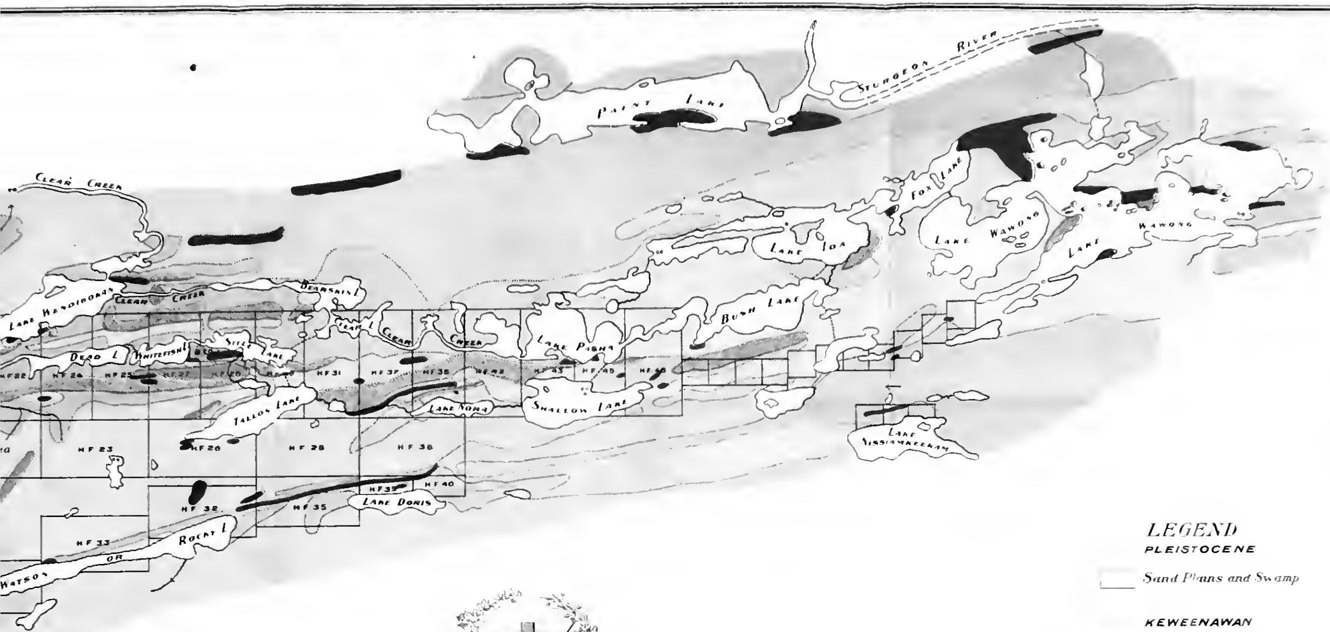
At several places along the river large deposits were noticed which consisted of alternating bands of clay and sand. This arrangement on being cut down by the river gives a rough sculptured effect, similar in character to that found in the Bad Lands of Montana, Wyoming and South Dakota.

In correlating the exposures found on the Pic river with those observed on the line, it is interesting to note that the garnetiferous biotite schist which is found on Mackay's lake and has been referred to the Huronian, would if produced to the line cut it at about the point where the garnetiferous biotite schist is found. That the rock found on the lake about thirty chains west of forty-three miles twenty-five chains may be Keewatin, obtains some support from the fact that the outcrop of a Keewatin schist which was found seven and a half hours or approximately thirty-five miles below Lake Superior falls is nearly west of the above mentioned outcrop.


MAP
OF THE
ONAMAN IRON RANGES
TO ACCOMPANY REPORT ON IRON RANGES EAST OF
LAKE NIPIGON BY E.S. MOORE. 17TH REPORT BUREAU OF MINES
1908.
SCALE 2 IN. - 1 MILE.
E.H. HARCOURT CO. LIMITED, LITHO TORONTO
LEGEND
PLEISTOCENE
Drift and Lacustrine Deposits
KEWEENAWAN?
Diabase and Gabbro
LOWER HURONIAN
Conglomerate
LAURENTIAN
Granite
Iron Formation
KEEWATIN
Porphyry
Greenstone & Green Schists
TRENCHING, STRIPPING & TEST-PITTING.
TRAIL
N
Height of Land Claims
Maple Leaf Claims
Winter Camp Claims
Miller Claims
Johnson Creek
Johnson Creek
Willow Lake
Red Point Lake
Red Point
Camp
Cache
Camp
Camp
River
Drill Hole
Creek



LAKE NIPIGON
Sturgeon River
Rapids
Falls
Long Rapids
Lake Corrigan
Lake Ela
Sand Creek
Standing Stone Lake
Goose Neck Lake
Dragon Fly L.
Poplar Lodge
Camps
Road
POP



IRON RANGES,

DISTRICTS OF

POPLAR LODGE AND LAKE WENDIGOKAN

SCALE -- 1 MILE TO ONE INCH.

HON. F. COCHRANE, MINISTER OF LANDS FORESTS AND MINES.

TO ACCOMPANY REPORT ON IRON RANGES EAST OF LAKE NIPIGON BY A.P. COLEMAN, ASSISTED BY E.S. MOORE, IN THE SEVENTEENTH REPORT OF THE BUREAU OF MINES 1908.

E H HARCOURT CO. LIMITED LITHO TORONTO

LEGEND

PLEISTOCENE

Sand Plains and Swamp

KEWEENAWAN

Diabase and Gabbro (Possibly some rocks older than Keweenawan)

LOWER HURONIAN

Arkose (Part may be Keewatin)

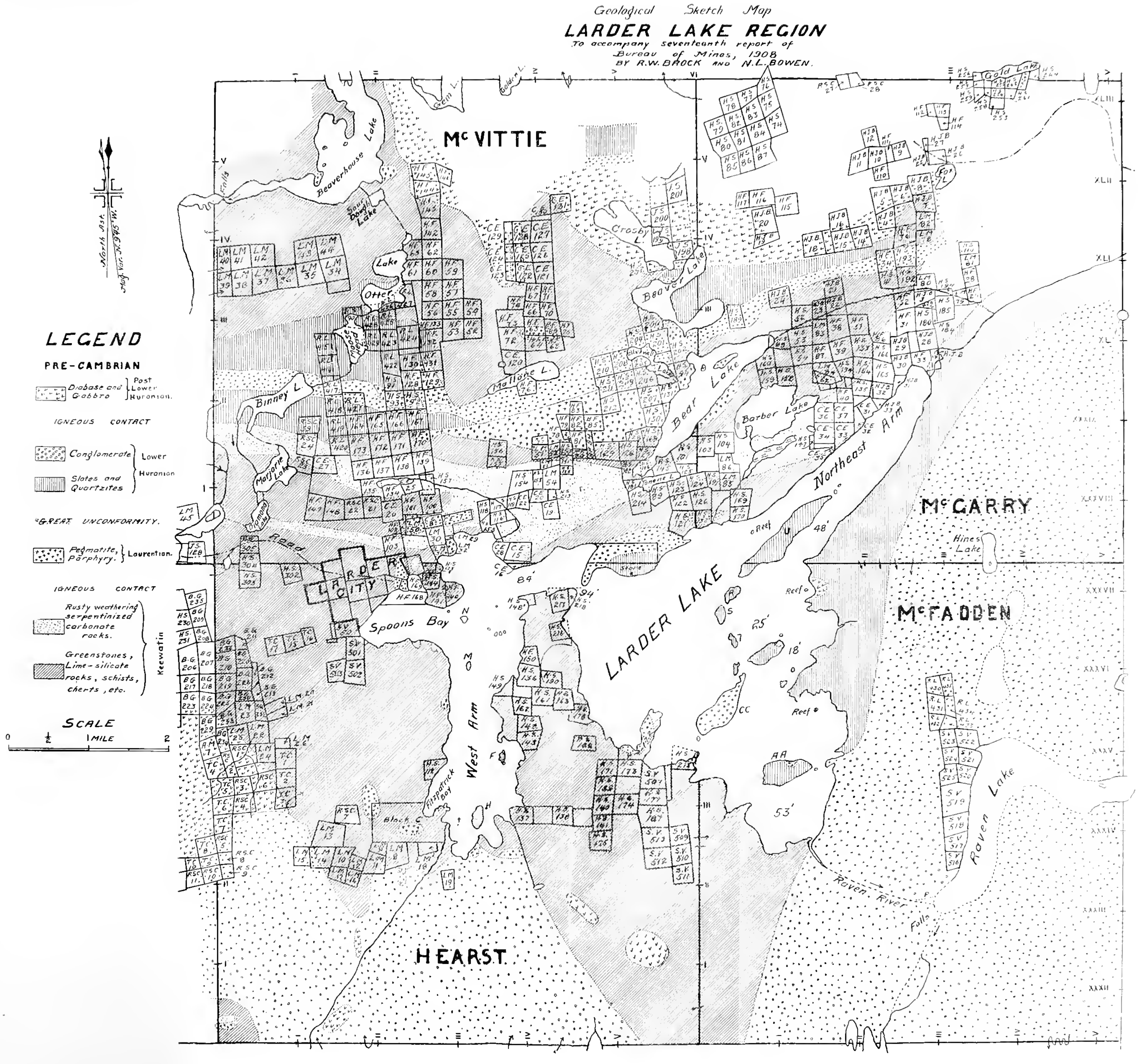
Conglomerate

KEEWATIN

Iron Formation

Carbonate Schist

Green Schist, Greenstones, Ancient Lavas.



Geological Sketch Map
LARDER LAKE REGION
To accompany seventeenth report of
Bureau of Mines, 1908
BY R.W. BROCK AND N.L. BOWEN.
LEGEND
PRE-CAMBRIAN
Diabase and Gabbro
Post Lower Huronian.
IGNEOUS CONTACT
Conglomerate
Slates and Quartzites
Lower Huronian
GREAT UNCONFORMITY.
Pegmatite, Porphyry.
Laurentian.
IGNEOUS CONTACT
Rusty weathering serpentinized carbonate rocks.
Greenstones, Lime-silicate rocks, schists, cherts, etc.
Keewatin
SCALE
0 ½ 1 MILE 2
McVITTIE
McGARRY
McFADDEN
HEARST
LARDER LAKE
LARDER CITY
Beaverhouse Lake
Binney L.
Marjorie Lake
Diamond Lake
Otter L.
Crosby L.
Beaver Lake
Bear Lake
Barber Lake
Mallone L.
Gold Lake
Fox L.
Hines Lake
Raven Lake
Raven River
Falls
Spoons Bay
West Arm
Northeast Arm
Fitzpatrick Bay
Road

Acknowledgments

In concluding, the writer wishes to express his appreciation to Mr. Brisbois, keeper of cache 10 and Mr. H. J. Farr, keeper of cache 10A of the Transcontinental Railway line, for hospitality extended to him. He also wishes to acknowledge his indebtedness to Mr. Peter Godchere, manager of the post of the Hudson's Bay Company on Long lake, for hospitality and assistance in mapping the portages on the Pic river. He desires to make acknowledgment to Professor A. P. Coleman and Professor W. A. Parks of the University of Toronto for valuable assistance in the determination of the geologic age of the rocks found. Finally, he desires to express his appreciation of the uniform kindness and courtesy of Mr. Alexander Niven, O.L.S., without whose advice and assistance it would have been almost impossible to carry out the work to its completion.

I.—IRON RANGES EAST OF LAKE NIPIGON

BY A P COLEMAN, assisted by E S MOORE

Introductory

During the past two summers work has been carried on by the writer and his assistants, in accordance with the instructions of Mr. T. W. Gibson, Deputy Minister of Mines, on the Iron ranges east of lake Nipigon, near Poplar Lodge and the Sturgeon river. In 1906 Messrs. Moore and T. L. Goldie acted as assistants; in 1907, Mr. Moore and Mr. W. F. Green: all three proving intelligent and faithful in their work, portions of which were carried on by Mr. Moore independently.

It has long been known that the Iron formation exists in the lands formerly mapped as Huronian east of lake Nipigon, and a number of geologists have made brief references to the region, but without making any serious geological study of the relationships of the Iron ranges. References to former work will be found in the section of this report dealing with the Nipigon or Keweeenawan formation.

Until the summer of 1906 the only detailed investigation, east of lake Nipigon, had been made by Mr. R. H. Flaherty and Prof. A. B. Willmott for economic purposes; and these gentlemen were good enough to provide blue prints or tracings of the result of their work, which proved of much assistance in planning our field operations.

Prospectors have scoured the region pretty thoroughly, and practically all of the Iron formation has been taken up as claims, which extend with few breaks from near Poplar Lodge on the shore of lake Nipigon to lake Wawang, twenty-one miles inland. The only gap in their work is caused by a band of diabase, which cuts across the range about seven miles from lake Nipigon.

The greater part of these claims have been surveyed later as locations of various sizes, from 40 to 320 acres; but a few towards the eastern end have not yet been surveyed. Many of the locations are not known to contain outcrops of the Iron range, but were taken up along the direction of known outcrops, with the idea that the formation probably continues beneath areas of drift or muskeg. The well cut out lines of the locations have been of great assistance in working out the geology, which has been fixed in most cases by pacing from corner posts, and making offsets on compass lines. In most of the region there is no disturbance of the compass, but along certain parts of the range, where magnetite occurs, the dial compass had to be used.

In last year's Report details were given of most of the rocks near Poplar Lodge and lake Wendigokan, and a sketch map was published, showing the distribution of the Iron formation.[1] This year some critical points were gone over again, and the mapping was carried as far east as the Iron range has been found. A geologically colored map has been prepared, showing the result of both years' work; and it is intended to take up the geology in a general way for the whole region in this Report, going more into detail in the parts not referred to last year.

Acknowledgments are due not only to Mr. Flaherty and Prof. Willmott for assistance in various ways, but also to Mr. P. A. Leitch of Nipigon and to the Geological Survey, all of whom aided us with maps and information.

Several of the prospectors who discovered the outcrops and took up claims at various points have served as guides, so that probably everything that shows much promise has been examined by us. Most of the topography, such as the forms and relations of lakes and rivers, we have had to revise from former sketch maps, or to survey afresh, so as to have a fairly complete foundation on which to plot the geology.

Physiography

The western third of the region mapped includes ranges of rocky hills on the north and south and a broad area between mainly covered with old lake deposits of silt or sand, or peat bogs, through which rise a few comparatively low hills of rock.

[1] Bur. Mines, Part I., 1906, Iron Ranges East of Lake Nipigon, A. P. Coleman and E. S. Moore.

The highest points do not reach more than 400 or 500 feet above lake Nipigon, which is 852 feet above the sea. There are a few small lakes and streams, but the only important body of water is the Sturgeon river, which is next the largest affluent of lake Nipigon.

East of the range of diabase hills which separates the Poplar Lodge ranges from those of lake Wendigokan the country changes a good deal, containing a multitude of lakes, more than sixty in the district mapped, of all sizes, from mere ponds to bodies of water four miles long and a mile and half broad, almost all tributary to the Sturgeon river. Rock crops out on many of the shores of the lakes, and sand plains occupy less space than west of the diabase hills. The map indicates the larger tracts of drift or muskeg by a separate color. It is, however, probable that patches of rock occur in the areas thus colored, since the field work was largely confined to the Iron formation and its surroundings.

All the physical features of the country, ranges of hills, lake basins, rivers and the iron range itself, are stretched out in a direction a little north of east and south of

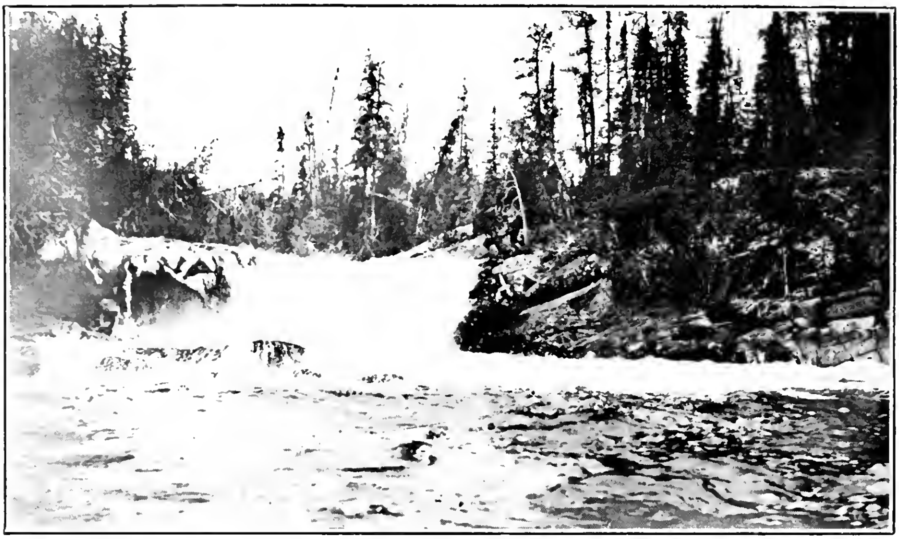
Sturgeon river.

west, corresponding to the strike of the schistose structure of the rocks; due probably to parallel folds caused by lateral pressure from upwellings of granitoid gneiss on each side, beyond the limits mapped.

The two southern Iron ranges near Poplar Lodge can be reached by trails running inland from lake Nipigon, the northern one by the lower reaches of Sturgeon river. The ranges near Wendigokan and eastwards must be reached by canoe on Sturgeon river as far as the range of diabase hills, and beyond this by a chain of lakes affording easy canoe navigation for about fourteen miles.

Sturgeon River

Sturgeon river averages about one hundred yards in width near its mouth, with a gentle current for three and a half miles up to the first rapid, which has a fall of nine feet over greenstone. About two miles above this there is a fall in two stages, with a total drop of thirty-eight feet, over greenstone, followed by two and a half miles of swift water with two riffles, which can be run coming down. The river up to this is somewhat winding with steep banks of silt and sand except where rock crops



Falls on Sturgeon river.

Falls on Sturgeon river.

out at rapids, and its valley has a direction considerably north of east. Here its channel suddenly turns north and crosses a broad ridge of diabase as a succession of rapids and falls a mile long.

At the lower end of the rapids two portages start, one to the north more than a mile in length, the other to the east more than two miles long, both running much of the way over the hilly surface of the diabase. Going eastward it is best to avoid the heavy currents of the river above the long rapids, by portaging to lake Corrigan, which is narrow and about a mile long, and then taking a portage of about a mile and a quarter, interrupted by a pond, near the east end, to lake Wendigokan. After these long portages the rest of the Iron range may be easily reached by a chain of lakes with navigable creeks or short portages between.

The river above the long portage where it has a fall, estimated by aneroid at 78 feet, makes a long irregular curve to the northeastward, then suddenly bends south toward the east end of Paint lake. This part of the river has numerous short rapids, some of which can be run, and alternations of swift and slack water between. Most

Poplars, Sturgeon river.

of the rapids are over ridges of green schist, though some are over boulders with no bed rock visible. As this bend leads much to the north of the Iron range it has not been included in the map.

Near the end of Paint lake the river is sluggish and wide with marshy banks, though the lake itself is mostly rock rimmed. From the end of the lake the course of the Sturgeon river bends eastward again, and two or three miles to the east the canoe route from Wawang lake comes in.

Seven or eight miles beyond, the river expands into Sand lake, and four or five miles farther east opens out into Battle Island lake, the last point to the eastward reached during our field work, since no Iron formation or other locations have been reported beyond. Battle Island lake has an elevation of 1,044 feet, as determined by hand level or estimate at the short rapids and falls, and by aneroid on the longer portages. The highest fall between this lake and the long rapids is of twenty-one feet.

Sturgeon river has brown water, but otherwise is a most picturesque stream, with a great variety of scenery along its banks. If mining operations should be undertaken

on any part of the Iron ranges power could easily be developed at several of the falls, though the difference in level between high and low water is several feet.

The Sturgeon is still a large river where it passes through Battle Island lake, more than 45 miles from its mouth, and must drain a large area to the east and north, but there are no reliable maps of its head waters, and we had no reason to carry our survey beyond this point.

Lakes of the Region

West of the diabase hills, which form a natural boundary between the two parts of the region, the lakes are comparatively few and small, drained by Sand creek, which enters lake Nipigon at Poplar Lodge. East of the diabase band there is a perfect labyrinth of lakes, mostly draining through Clear creek into the Sturgeon above the long rapids. The canoe route begins with Corrigan lake, which has an outlet of its own, through an unnavigable creek into Sturgeon river; then crosses a low water shed to Wendigokan lake, three miles long from west to east, and with numerous bays and islands. Its shores are partly of sand, but include many outcrops of rock. Clear creek, which flows out northwest from its east end towards Sturgeon river, enters the lake only half a mile to the south. The water is crystal clear, so that all the fish can be seen as one follows the windings up to Bearskin lake on the east. There is a rise of about five feet between the two lakes, but no rapid. From the south side of Bearskin lake the creek with some marshy expansions and even more numerous curves can be followed to Pasha lake, which is about a mile long and about ten feet higher up. From its eastern end a tangle of small lakes and bays with three narrows leads to Bush lake, from which there is a short portage north into lake Ida, two miles long, and a canoe route eastwards through Fox lake into lake Wawang, about four miles long and a mile and a half wide, the largest of the whole chain of clearwater lakes.

There is a smaller chain of lakes running nearly parallel less than half a mile south, as may be seen from the map, but connected by smaller creeks, which are unnavigable for canoes. They drain through Still lake, Whitefish lake and Dead lake, which is shallow and with mud bottom, into the southern bay of lake Wendigokan.

Most of the shore along all these lakes is of low sand plains or marsh, but on almost all of them there are outcrops of rock, usually rising but little above the surface. The highest of these lakes is probably not more than twenty-five feet above the lowest, and the whole series occupy comparatively shallow basins, separated only by flat plains or muskegs.

The Iron formation is easily reached in almost all its parts from one or other of these lakes, and the boundary lines of the locations very often come out on their shores, so that they form the natural highway for anyone wishing to follow up the work that has been done.

Classification of the Rocks

The region mapped from Poplar Lodge eastward contains a considerable variety of rocks, all very ancient except the Pleistocene drift and old lake deposits, which will be taken up later. They are all pre-Cambrian, with the exception of certain diabases which may be of Keweenawan age or perhaps a little later. The classification used is that recommended by the Correlation Committee, and may be tabulated as follows:

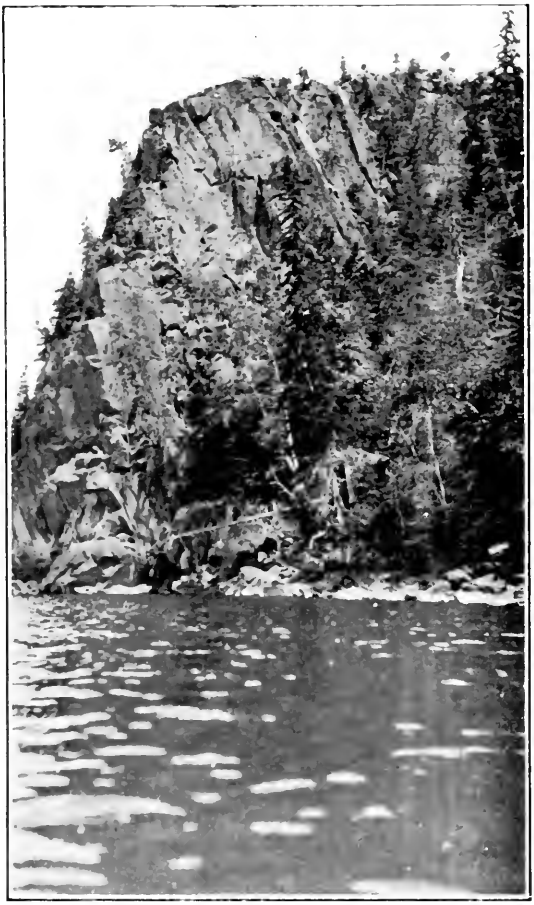
KEWEENAWAN	Basic eruptives, diabase, gabbro, etc.	
ARCHEAN	Lower Huronian—Conglomerate, and probably slate and arkose.	
	Keewatin	Iron Formation, with some slate schist and arkose.
		Green and gray schists, sometimes sideritic.
		Greenstones, green schists and volcanic.

The only undoubted Lower Huronian rocks are the conglomerates, but certain slates and arkoses associated with them are probably of the same age The Keewatin covers much the larger area and includes a variety of eruptives, both deep seated and

volcanics, as well as sedimentary rocks on a smaller scale, the Iron formation being the most important. All of the Keewatin rocks have undergone much alteration by compression at right angles to the strike and by metamorphism, and often the original minerals have been completely rearranged into secondary minerals.

Keweenawan Eruptives

The only solid rocks later than the Archean are the diabases, approaching gabbro in character, which form bands or bosses rising as ridges or hills in various parts of the region, their area being often small, though sometimes large. These rocks are dark gray, and range from fine-grained near the edge to quite coarse-grained at a distance



Keweenawan cliff, Humboldt bay, Lake Nipigon.

from their contact with other rocks. They show no arrangement in sheets and have no columnar jointing, points in which they differ from the diabases of the Keweenawan sills found at various points on the shore of lake Nipigon and the Nipigon river. As the rock in thin sections is an olivine diabase resembling that of the Keweenawan sheets, it may be supposed that these irregular masses or bands are the more deeply seated parts of the Keweenawan basic eruptives, perhaps representing the channels through which the molten rock ascended.

The largest area of diabase separates the Poplar Lodge iron ranges from those to the east, and has a width of two miles from east to west at its widest. Towards the

south it is lost under sand plains and muskeg, but it rises as steep hills with an uneven surface to the north as seen on portage trails. Where crossed by the Sturgeon river in the long rapids, it turns westward and perhaps extends to the shore of lake Nipigon, where diabase is found, but this part of the region has not been touched at many points in our work.

Another considerable area is found at the southwest corner of the map, where the Iron range is apparently cut off by it. Though partly covered by swamp, this area appears to have a length of three miles and a width of at least one mile. Numerous smaller patches and bands of diabase are represented on the map, many of which seem, however, to be more ancient, since they have undergone much more weathering than the usual Keweenawan diabase.

None of the Keweenawan sedimentary rocks have been observed in the region mapped, though they occur farther south and farther north along the shore of lake Nipigon. Except as interrupting the continuity of the Keewatin rocks which contain the various Iron ranges, the diabase just referred to have not much practical importance, and the areas covered by them have been studied only incidentally. There are very few diabase dikes so far as observed, compared with most parts of the Archean of northern Ontario, the molten rock having eaten or pushed its way up with quite irregular boundaries in most cases instead of filling long continued fissures.

The Lower Huronian

The Lower Huronian conglomerate is of much importance geologically as affording a well defined horizon for the subdivision of the Archean, since it represents the greatest break in time of which we have evidence in the lake Superior region. It has also some practical importance, since it affords the best guide in working out the synclines where ores may be concentrated along the Iron ranges.

Only small areas of conglomerate are found west of the diabase band, but east of it a broad belt extends along the north side of the region mapped for 15 miles or more. As it was not followed from point to point, but touched only at intervals of half a mile or a mile, our map represents this band as more discontinuous in all probability than it really is. In width it runs from a few feet to a third of a mile, but is generally 100 or 200 yards wide.

As seen from the map there are many smaller patches of conglomerate, frequently only a few feet wide, but generally elongated in the usual direction of the strike, and often near bands of the Iron formation and parallel to them. The conglomerate is generally quite schistose, with the softer pebbles rolled out to lenses, though harder ones, such as the granites, may keep their original shape. The schistose cleavage follows the general strike of the region, a little east of north, and always has high dips. The stratification, as shown occasionally by bands with many or few pebbles, seems to run in the same direction, but in most cases the bedding is not easily determined.

The rocks enclosed as pebbles or boulders include almost all the kinds found in the Keewatin with the addition of granite, derived from the neighboring regions. The list includes granite, aplite, diorite, felsite, porphyry, greenstones and green schists, white vein quartz, jasper and other varieties of the banded silica of the Iron formation. The stones range from the smallest pebbles up to boulders two feet in diameter, but very large ones were not often seen. They are generally well rounded, where not distorted by pressure, but some are subangular. They are often much crowded, but occasionally sparsely scattered. Near Corrigan lake, at some localities, the pebbles have been squeezed against one another till the harder ones dented and impressed the softer ones as if they were plastic.

In most places the conglomerate appears to be waterformed, and not the result of immediate glacial action, though the number of large granite boulders brought down from a distance of at least some miles is suggestive of ice transport, the materials being rearranged afterwards.

The matrix of the conglomerate is a somewhat re-crystallized arkose containing angular fragments of quartz and feldspar, and resembles the matrix of ancient boulder clays.

Certain slaty schists and arkoses closely associated with the conglomerate also probably belong to the Huronian, though no definite order of succession has been worked out.

The whole of the Lower Huronian rocks studied are sediments of one kind or another, no eruptives having been found; and these sediments could not have been laid down until profound erosion of the Keewatin rocks and the granites which penetrate them had taken place, to provide the vast quantities of pebbles, boulders and finer materials needed for beds of rock hundreds of feet or even more than a thousand feet thick and several miles in length. The break between the Lower Huronian and the Keewatin and Laurentian must therefore have been of very long duration, allowing the lower rocks to be thrust up by mountain building forces, and to be exposed for ages to the erosive work of frost and weather and waves before the conglomerate was formed of the fragments and laid down upon the originally eroded surface.

Rocks of the Keewatin

The Iron Formation

The Iron formation is the highest or almost the highest part of the Keewatin, and extends as long bands, with many gaps, from end to end of the region mapped. It provides almost as definite a horizon as the conglomerate just described, but the bands are in general found to be narrower. In some places three parallel bands a mile or two apart may be distinguished, but this is by no means the case everywhere.

The materials of the Iron formation in the Nipigon region are always silica in some form and an oxide of iron, magnetite or hematite, never siderite nor sulphides as in the Michipicoten region. There are two types of the formation, one consisting of interbanded quartzitic or cherty silica with magnetite, the other of jasper with hematite, but there are mixtures of the two varieties in many places.

The dark variety of the Iron range is often intermixed with a gray slate, and the leaner parts seem to grade into the latter rock, containing less and less magnetite until the compass is no longer affected.

The jaspery variety is a very showy rock with bands of bright red and glistening black hematite, intricately folded and crumpled, and cut by narrow veins of white quartz which have also been crumpled. The actual jasper and hematite may be in rather narrow elongated strips with gray schist between, so that a cross section may show many alternations of banded jasper and schist instead of continuous jaspery material as in most iron regions near lake Superior.

Intermediate varieties between the extremes described may contain magnetite enough to make the compass useless, along with some strips of dull jasper and so much hematite that the powder of the ore is red when pounded with the hammer.

There is one small tract of Iron formation on Black river, a few miles to the southwest of the main succession of ranges, which is of an entirely different character from the others. The silica is in the form of coarsely granular gray or rusty bands an inch or two wide with a small amount of magnetite or none at all, looking like sandstone rather than chert or jasper. This variety resembles rather closely some phases of the Michipicoten ranges near the Helen mine: while the first varieties described are more like the Iron formation of Michigan or Minnesota.

It is probable that all the varieties began in much the same form, but have been affected by mountain building stresses to varying degrees, the jasper-hematite being least modified, the cherty-magnetite more so, and the coarsely granular silica from Black river most of all.

Rocks associated with the Iron Formation

The Iron formation described above seldom occurs in broad bands without intermixture of other rocks, especially slate or phyllite and various schists. The slaty rock may be looked on as merely an extreme variety of lean Iron formation, in which the magnetite or hematite has reached the vanishing point. Some slates that have no effect on the compass and are comparatively light in color and in weight, yet show a reddening when pounded with the hammer, indicating a small amount of hematite.

None of the slaty rocks examined in the Nipigon region contain any appreciable amount of carbon, thus differing from the slate accompanying the formation at the Helen mine.

Two kinds of schists are commonly found interbanded with the Iron ranges or close to them, one gray and quite schistose, consisting when examined under the microscope,

Shore, Lake Nipigon.

of the materials of arkose, and angular fragments of feldspar and quartz, with mica or chlorite enough to give a schistose cleavage. The schistose arkose and the slate or phyllite, for these two rocks sometimes pass into one another, are ordinary sediments, not chemical sediments as some have supposed the silica and iron oxide of the Iron formation to be.

Another kind of schist associated with the iron-bearing rocks, which is green and very cleavable, may be called chlorite-carbonate schist, and is perhaps a greatly sheared and rearranged basic eruptive in origin.

Actual carbonate rocks are rare and do not seem to be closely connected with the iron ranges, occurring often a mile or more from any known outcrops. The carbonate has the composition of ankerite or impure dolomite, and contains iron enough to weather rusty. The fresh material is pale yellowish, and does not effervesce with cold acid. The carbonate rocks are more or less schistose, and seem to belong to the Lower Keewatin rather than the Iron formation.

Lower Keewatin Rocks

Nine-tenths of the region mapped, if drift and peat covered areas are excepted, consists of schists and eruptives of the Lower Keewatin, mostly formed from basic eruptive materials, though there are some schistose arkoses containing a good deal of

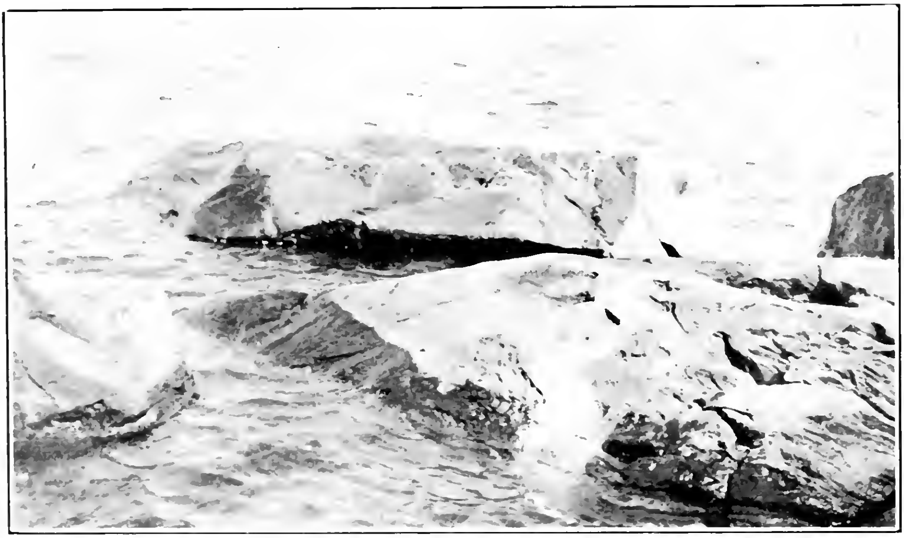
quartz, some pale green schists containing carbonates and quartz, and some rather acid plutonic rocks like diorite or grano-diorite. All the Lower Keewatin rocks contain chlorite or hornblende enough to give them a green color.

Except the arkose, which consists of materials probably assorted and distributed by water, the Lower Keewatin rocks are of eruptive origin, either deep seated or coming to the surface through volcanoes.

Volcanic Rocks

Where the greenstones and green schists are exposed on clean surfaces, as along the shores of lake Nipigon, they generally show the character of volcanic materials, including amygdaloids, pillow structure and breccias of volcanic fragments. Probably, too, some of the more schistose rocks are rearranged volcanic ash.

The points and islands at Poplar Lodge, and the large promontory north of the mouth of the Sturgeon river consist almost entirely of greenstones showing these structures, though often rather obscurely, as might be expected in rocks so ancient. The



Breccia, near mouth of Red Paint river.

amygdules, holes formed by steam bubbles afterwards filled with secondary minerals such as quartz and epidote, are usually small and found only at certain levels, the upper parts of lava flows. The pillow structure, representing the crust of lava streams broken and rolled along by the still fluid lava below, is very well seen on clean weathered surfaces on some of the islands, but freshly broken surfaces scarcely show the structure at all. The volcanic breccia north of the mouth of Sturgeon river is best displayed on ice-smoothed surfaces wet by the waves. The bits forming the breccia are angular, not at all water rounded, and consist almost entirely of felsites and fine grained porphyrites, all green, but of varying tints. None of the fragments are more than a foot or two in diameter, and no granite nor jasper pebbles occur among them, so that they are very different from the Huronian conglomerate found not far away. The matrix of the breccia consists of smaller angular fragments of the same kind.

At several places inland, viz., along the north shore of lake Eva, the amygdaloidal and other volcanic structures are seen, and it is probable that volcanic rocks are really very widely spread; but on moss and lichen covered surfaces these features can hardly be recognized, so that it has not been possible to map these rocks separately from the other greenstones.

Probably many of the widespread green schists are also volcanic in origin, having been formed in the first place by showers of basic volcanic ashes.

Deep Seated Eruptives

In many places, especially along the north shore of Sturgeon river near its mouth, there are bosses and irregular eruptions of various kinds, from gabbro to grano-diorite, closely intermixed with the other members of the Keewatin, no doubt later in age than the rocks they penetrate but probably earlier than the Lower Huronian, since the conglomerate of the latter age contains boulders or pebbles of what appear to be the same rocks.

The gabbro-like rocks are greatly weathered, and the more acid plutonic rocks (such as diorite and grano-diorite) have also undergone a good deal of change, though their constituent minerals can still be distinguished. Undoubted granite has been found in the district mapped only once or twice, as dikes, though Laurentian granite and gneiss occur some miles away, both to the north and the south.

These ancient eruptives seldom cut the Iron ranges, perhaps because they are older; but one small band of weathered gabbro has broken through the Iron formation in A L 414, and has caused concentration of iron on a small scale, in the form of pockets of hematite, richer than usual. This elongated mass of gabbro may, however, belong to the Keweenawan eruptives, rather than those of the Keewatin.

Except that the plutonic eruptives, such as diorite and gabbro, are younger than the surface lavas which they penetrate, no definite order of succession has been worked out for the complex of greenstones and green schists of the Lower Keewatin.

Distribution and Associations of the Iron Formation

The Poplar Lodge Ranges

The earliest found of the Iron range outcrops were naturally along the shore of lake Nipigon where first a northern and a southern, and later a central range were located. As details of the geology of these locations have been given in the last Report of the Bureau of Mines,[2] it will only be necessary here to give a general account of the three ranges and the rocks which enclose them.

The Northern range has a length of about a mile and a quarter, running northeastwards through locations A L 408, 407, 406, 405, 404, 403, 402, near the north bank of Sturgeon river two or three miles from its mouth. It is seldom more than fifty feet wide, but reaches a width of 240 feet, with intermixed slaty rock at one spot on A L 403. In general the banded silica lies just to the southeast of a ridge of greenstone, under which it dips at an angle of 35 to 60 degrees. On the opposite side the Iron formation generally runs under old lake deposits towards the river bank.

Both magnetite and hematite occur, though the latter shows red only when powdered. The silica bands are generally cherty or quartzitic, with occasional strips of dull jasper. On the whole the range is too narrow and lean from the admixture of silica and slate to be very promising.

The Central range is three miles south of the northern, and is first seen a mile and a half inland from Poplar Lodge. This part of the region is mostly covered with sand plains and swamp, so that solid rock does not crop out very frequently and then only as low rounded surfaces, making it difficult to prospect without doing much stripping. A considerable amount of work has been done in this way, and three diamond drill holes have been sunk on the most important outcrop, but undoubtedly much of the range still remains covered. The known outcrops are in four localities, (1) A L 414, (2) at the north end of A L 413 and 412, (3) at the southern edge of A L 413 and in A L 416 and H F 1 and (4) in H F 5. The third area is the most attractive and has been most thoroughly prospected, showing a widespread series of bands of Iron forma-

[2] Vol. XVI, pp. 115-128.

tion over a length from east to west of half a mile and a breadth of a quarter of a mile. Including all four outcrops the range has a length of nearly three miles, with a breadth of about three-fourths of a mile where widest, but these limits include much drift-covered surface and barren rock, and the most easterly outcrop is separated from the others by a mile and a half in which no Iron formation has been found.

The ore is entirely hematite, and the associated silica is jasper, often bright red. In the areas mapped as Iron range more than one half consists of grey and green schist in which fragments and long strips of the Iron formation are imbedded, and in general the jaspery strips tend to run out into schist toward the east and west. A narrow belt of Huronian conglomerate runs parallel to several of the outcrops, and is occasionally repeated several times as in location A L 414. This seems to indicate a number of small parallel folds as the structure, so that the great width of this range is probably due to repetition. In one place on the boundary between A L 413 and 416 a diamond drill hole showed jasper and ore 414 feet below the surface, so that the synclines are not shallow.

Indian encampment, Poplar Lodge.

The Southern range has a length of seven miles, including interruptions of drift and barren rock, and a width at greatest of 500 feet, though generally not more than a tenth as wide. It is separated from the nearest point of the Central range by three-quarters of a mile of greenstone and schist rising as a ridge. The Southern range contains much magnetite and resembles the Northern range, though much more extensive, and also richer in iron. The associated rocks are slate, and gray and green schists, and the range fades out laterally into the other rocks. The arrangement is unsymmetrical, the richest and most magnetic ore generally occurring on the north side of the range, while leaner bands are interbedded with slate or schist to the south. The general direction of the range is north of east, following the usual strike of the region, and the dip, like that of the Central range, is high, from 60 degrees to vertical.

The contrast between the narrow Northern and Southern ranges with their dark colors and magnetitic character and the broad Central range with its bright red jasper and shiny hematite is very great, and is perhaps to be accounted for by supposing that the outer ranges were most severely squeezed and metamorphosed when the folds and schistosity of the region were developed, the Central range being more protected and therefore less changed.

The Wendigokan Ranges

For some miles eastward of the diabase hills which separate the ranges just described from those inland it is no longer possible to distinguish three ranges. Near lake Wendigokan which has been mapped and described by Mr. Moore[3] there appears to be a continuation of the Northern range but not of the others. Details in regard to distribution may be found in his report, so that here it will be necessary only to give the general character and relationships. The most important outcrops are west of the lake, in locations H F 13, 12, and 10, and southeast of it near Still lake in location B T O 1. In the western area the Iron formation is wide and consists of banded jasper and gray slate, but there is much schist in portions of the range, which runs out towards the east and west into schist, the length exposed being about half a mile.

The area near Still lake is a little shorter, but has a width of 450 feet in the middle, part of it, however, being hidden by drift. The Iron range is very silicious here as in the other area, the last assays of samples running from 35.75 to 36.86 per cent. of iron; and there is no indication of any secondary accumulations of ore.

Farther to the east there are two narrow parallel bands of the Iron formation, neither continuing the strike of those just described. The longest runs from the northeast end of Watson lake for nearly two miles, beginning in location H F 32, and ending in H F 40, with a greatest width of about 100 feet. The iron-bearing rock consists of magnetite and jasper with green slaty schist on each side. The richest specimen of magnetite collected from it runs 48.9 per cent. of iron.

The general character of these outcrops of the Iron formation is like those of the Northern and Southern ranges near Poplar Lodge, always containing more or less magnetite, yet with some hematite and jasper. There seems to be no equivalent of the Central range in which no magnetite occurs.

Geology near Corrigan Lake

As Mr. Moore's work in 1906 included only the Iron formation and the locations enclosing it in the Wendigokan region, it seemed advisable to extend the study of its geology so as to connect up with the Poplar Lodge region to the west, and to add a tract to the north. Excursions west and south of Corrigan lake disclosed broad sand plains and muskegs with comparatively few outcrops of rock, all diabase for two miles to the south, then greenstone and green schist of the Keewatin.

To the north of Corrigan lake a broad band of Lower Huronian conglomerate rises as steep ridges with a width of nearly a quarter of a mile in all, including some narrow valleys floored with muskeg. The conglomerate is sometimes much squeezed, but often has its pebbles fairly well preserved. They consist of granite, quartz porphyry, greenstone, etc., the harder ones well rounded, the softer ones rolled out and bent round the others. The schistose structure strikes in the direction 70 degrees and stands about vertical, following the usual arrangement of the region. To the north, as far as explored, the rock is greenstone, and it is probable that the band of conglomerate is of synclinal shape, so that its true thickness is only 600 or 700 feet. A few dikes of porphyrite cut the conglomerate, perhaps offshoots from the diabase ridge to the west, which has a porphyritic development near Corrigan lake.

[3] Bur. Min. Vol. XVI, pp. 139-145.

The Keewatin greenstone observed to the north and south generally has pillow structure, indicating lava flows, but at one point southeast of the east end of Corrigan lake diorite occurs, evidently of deep seated origin. South of location H F 16 interbedded with the usual green schist or greenstone there are bands of carbonate schist, but no Iron formation was observed.

Geology North of Wendigokan and Bearskin Lakes

North of the west end of lake Wendigokan green schist and carbonate schist are encountered for half a mile, with a dike of coarse white granite on the line between H F 18 and 19. A small lake is then reached on whose north shore the continuation of the conglomerate referred to north of lake Corrigan is found, having the same characters as before, but a width of only 480 feet. To the east the band of conglomerate

Huronian conglomerate, lake Corrigan.

seems to run out, after an outcrop of three and a half miles, since only sand plains and green schist were observed from this to where Clear lake flows out of Wendigokan lake.

Beyond Clear lake, where it bends westwards near its outlet, the conglomerate appears again and runs eastward for about a mile. As mapped by Mr. Moore the previous summer, there is a narrow parallel band on the east shore of Wendigokan, which seems a continuation of a similar band at the west end of the lake. These are so much narrower than the northern band as to make it doubtful whether they are the same repeated by folding, or another conglomerate belonging to a different horizon.

Pasha Lake Region

As Mr. Moore's mapping ended with locations H F 38 and 40, where two narrow bands of Iron formation run out, the region to the east was taken up in detail, so that the Iron range and its associations could be satisfactorily mapped in continuation of the former year's work.

On the north shore of Pasha lake and on Clear creek and its expansions to the west, only sand plains and swamp are found for a width of more than half a mile. Beyond the drift Keewatin greenstone occurs, sometimes with a hint of pillow structure, but usually without.

South of the west end of Pasha lake arkose occurs, coarse and whitish gray, having a strike of 80 degrees and nearly vertical dip. This extends to Shallow lake, which runs parallel to Pasha lake a quarter of a mile to the south.

Dike of porphyry, Paint lake, Sturgeon river,

Near the middle of the south shore of Pasha lake a patch of conglomerate crowded with small pebbles rises from drift, and can be followed about 150 yards to the east, when arkose succeeds it and then gray schist. A small patch of bright red banded jasper lies below the water just west of a small point, but could not be traced on land, though the schists observed are of the kind often associated with the Iron formation.

Another small patch of jasper material was found a little north of Shallow lake and west of the line between H F 45 and 46, but this too could be traced only a few feet. The rocks between Pasha and Shallow lakes are chiefly gray slaty schist, with some rusty carbonate schist, varieties often associated with the Iron ranges, but no outcrops were found except the two mentioned.

South of Shallow lake hard greenstone with bands of green and gray schist are found for about half a mile, but to the east and west of the lake swamps hide the bed rock.

On location H F 46 Iron formation was found in two small patches toward the southern side, with gray schist and some carbonate schist. Most of the north half and part of the south half are drift covered or swampy.

Bush Lake, Lake Ida and Paint Lake

Location H F 46 is the last which has been surveyed, but a row of eleven claims of forty acres each extends to the east along the strike of the Iron formation. The first six of these claims consist very largely of sand plain and swamp, but a stretch of schistose arkose runs along the north side, and there are outcrops of slate like that found with the Iron range, and also greenstone and gray schist along the south side, but no actual jasper or ore was found in them. Bush lake has low swamps or drift-covered shores with a few outcrops of rock, all that was found being a little conglomerate at the end of the southwest bay, and Keewatin schists at the northeast end.

Lake Ida, reached by a short portage to the north, is also largely enclosed in sand

Shore, Wawang lake.

plains which rise about twenty feet above it. A little inland from its narrow western end greenstone, gray schist and arkose rise above the sand plain, and at the east end there is greenstone and arkose.

North of lake Ida greenstone, green and gray schist and porphyrite runs almost to the shore of Paint lake, where not drift-covered. Here and there broad outcrops of conglomerate show on the south shore of Paint lake, running parallel to its length and rising as steep ridges, often with a bay behind them to the south. The outcrops are probably remnants of a once continuous band. The pebbles include many bits of red jasper and of granite, which still have their original shape, but most of the others are flattened to lenses. The schistose structure has a strike of 60 degrees and a steep dip to the northwest.

Near Wawang Lake

Going eastward from lake Ida one passes first through Fox lake, which is surrounded with sand plains except for outcrops of conglomerate at each end, and then into the eastern bay of lake Wawang, the largest body of water in the region mapped. Most of its shores consist of swamp or sand, though considerable areas of conglomerate, of green schist and of arkose occur at various points, which need not be described in

detail. No outcrop of the Iron formation was found on the lake itself, but several occur in the row of small claims to the southwest.

The first claim, beginning at the west end of the southern bay of lake Wawang, is mostly covered with drift, but near its southwest corner greenstone and slate appear, with a band of lean Iron formation enclosed in the slate, and a hill consisting first of slate and then coarse diabase rises to the southwest.

The next claim to the southwest shows similar rocks, greenstone, green schist and slate, and the same is true of the third claim from lake Wawang, except that more of the Iron formation is found, near the southwest corner a few hundred yards east of Downey lake. Here there are two bands of hematitic slate, bright red in color, interbanded with greenish slates. A small stripping shows ten feet in width of the lean hematite in one place, with a strike of 70 degrees and vertical dip.

Nissiamkeekam Lake

A quarter of a mile south of the claims just mentioned, three or four other claims have been taken up along the north shore of Nissiamkeekam lake, including the best outcrops of the Iron formation seen east of Wendigokan. The country between includes greenstone, green schist and slate, and a little south of the north boundary of the claims the Iron formation is found by the side of a small ravine. It consists of jasper, "blue" hematite, and enough magnetite to make the compass useless, covering, with some slate, a width of about 60 feet. Specimens of the ore are the heaviest and purest collected during the work, but the solid ore is found only in narrow bands at most two or three inches thick. The range was traced by stripping the moss for more than 400 paces, with a direction of about east and west. The outcrop resembles the best parts of the Southern iron range near Poplar Lodge, but contains more hematite and less magnetite.

The rocks to the south and along the shore of the lake are largely gray slaty schist of the sort which often goes with the Iron formation, and have a strike of about 100 degrees with a vertical dip. The outcrop of iron ore runs somewhat across the strike, which probably represents merely the schistose structure, and not the original stratification.

Besides the two claims in which the Iron formation is well developed, another one has been cut out to the west and a fourth begun still farther west, probably taken up to include an extension, which was not found, however, in our field work.

As no outcrops of Iron formation had been reported east of lake Wawang for a number of miles, the survey was closed at this point and only resumed near Black river where a few iron claims have been taken up. Iron range was suggested on one of our maps to the west of Sand lake, an expansion of Sturgeon river, but we were not able to find claim lines or outcrops.

Black River Iron Claims

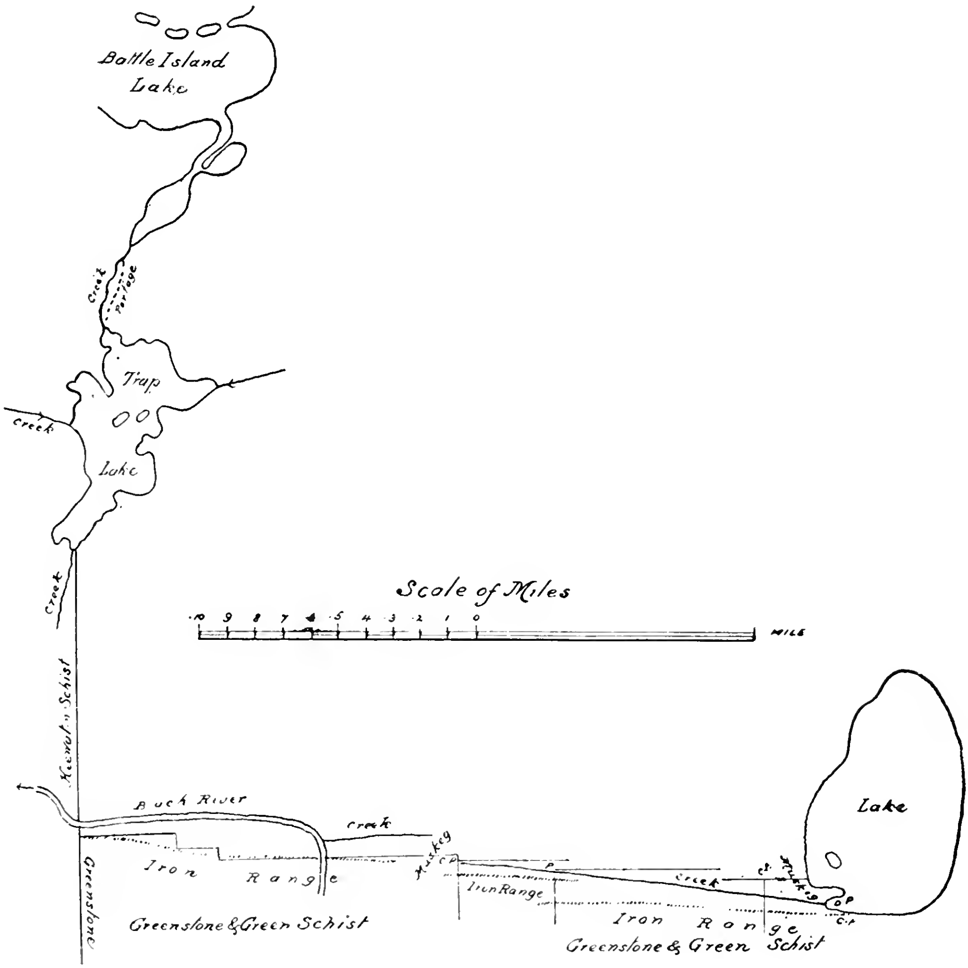
Leaving Wawang lake from near the middle of its northern bay a canoe route leads northwards through two ponds to Sturgeon river, which may be followed up stream east and southeast to Sand lake, then southeast to Battle Island lake, another expansion of the river. From its southern bay a portage leads south to Trap lake, from which Black river may be reached by a walk of about a mile and a quarter. On the way from Wawang to Sturgeon river green schist and conglomerate are encountered. Up the river mainly drift shows on the shores, but green schist was crossed on the portages, with a strike of 45 degrees, and vertical dip where these were observed.

Sand lake is enclosed partly by sand plains, as the name suggests, and partly by swamps, only one outcrop of rock being seen, conglomerate forming a small island.

Two and a half miles above Sand lake the portage past a rapid is over green schist, but beyond this no rock was seen on the river, the west end of Battle Island lake or on Trap lake, which probably got its name from its outlet being troublesome to find, since its shore are morainic, and no trap rock occurs. For nearly half a mile south of

Trap lake the country consists of morainic forms or sand plains. Then ridges of gray schist occur, striking nearly east and west, and having much the appearance of the Couchiching near Rainy Lake. Thin seams of harder materials, especially quartz, rib the surface.

Farther south some massive greenstone mingles with the schist which is now greenish, and has a strike of 80 degrees, and green schist of varying texture continues to Black river, here flowing westward near its head, as a creek easily bridged by fallen logs.



Iron Range on Black river.

Just south of the river ridges rises, partly consisting of coarse-grained rusty silica, a form of the Iron range not found elsewhere in the eastern Nipigon region, but very like some varieties near the Helen mine, Michipicoten. Banded sugary silica with a little magnetite, running east and west and with a dip of 80 degrees to the north, occurs in a width of five or six feet at this point, followed by dioritic looking greenstone and green schist, for 120 paces, when a belt of similar banded silica is met, having a width of 60 paces, beyond which green schist and hornblende porphyrite or diorite rise in hills to the south.

The bands of silica seem to be interrupted frequently, but were followed eastwards for more than two miles, narrowing and apparently running out near a small lake at that distance from a compass line due south from Trap lake. Though this strip of Iron formation is very like some of those in Michipicoten in the granular appearance of its silica, it seems too poor in ore to be of much promise. Bands of impure magnetite an inch thick were found in a few places, but much of the silica is almost devoid of ore. Occasionally dark green hornblende occurs in bands, the crystals often having a radiating arrangement.

The associated rocks are greenstones, green schists and amphibolites, and it may be that some of these eruptives are later than the Iron formation and have had a metamorphic effect, producing the coarsely granular quartz, so unlike the cherty or jaspery character of the silica in the other ranges near the east coast of lake Nipigon.

A thin section of the Iron range rock consists mainly of interlocking anhedra of clear quartz, often with films of brown iron oxide between them. Long, slender prisms of sillimanite grouped in bundles pierce the quartz individuals here and there, and a few crystals of magnetite occur also.

Very similar Iron formation is found near Fort Frances on Rainy river, where the rock was called Couchiching, and was looked on in earlier days as a sedimentary sandstone.

Near Half Way Point

It is probable that many small outcrops of the Iron formation are scattered over the region east of lake Nipigon buried under peat bogs or sand plains and thus far undiscovered by prospectors. An outcrop was observed on the shore a mile below Halfway point or Grant's point, as it is named on some maps, of a rather interesting kind petrographically, though of no economic importance, since it is less than 100 feet long and 20 feet wide. It is enclosed in greenstone and has been more or less torn asunder and the blocks shifted.

A thin section shows granular quartz like the last, though finer grained, through which are bands or flecks of a carbonate and a few scales of green chlorite. Some isometric crystals of iron ore, once magnetite, seem now to be hematite (martite), reddish black in color, occasionally with red streaks or bands running out from them into the quartz. Behind some of the larger crystals the quartz individuals and the slender strips of hematite are elongated and stream out as if in the lee of an obstruction in a current. Evidently magnetite has been further oxidized to produce hematite in this case.

A small amount of pyrite occurs also as crystals, giving a brown surface to the rock where weathered.

Relation of Laurentian to Keewatin

In the district mapped, Laurentian rocks do not crop out, but they occur not many miles to the south and to the north, and their pushing up from beneath is thought to have caused at least to some extent the folding and schistose cleavage, running about 70 degrees or 80 degrees, so characteristic of the iron ranges and their associated rocks.

The northern Laurentian area was studied at some points where exposed on the shore of lake Nipigon, and its relations to the Keewatin will be described.

Going north from the mouth of the Sturgeon river a volcanic breccia of Keewatin age forms the first promontory, and the same rock reaches half way into the next bay. Then come green schist and greenstone, with some pillow structure, having a strike of 60 degrees. Mungo Park point, like most of the other promontories on the east shore, is a sheet of diabase, hiding the older rocks; but in the bay just north of it Keewatin greenstones appear at the southeast corner and continue for a couple of miles to the mouth of a small river, where red granite begins.

The Keewatin rocks here include hornblende, porphyrite, ordinary green schist, and obscure amygdaloids, through which the coarse red granite has pushed up, carrying

off blocks and sending dikes of various kinds and sizes into it. The boundary between Laurentian and Keewatin is very sharp in most cases, and is emphasized by the difference in color, pink or flesh red in contrast with dark green. The batholith of granite has had little effect on the sharp edged blocks of greenstone near their source, but some smaller bits, probably carried farther and digested for a longer time, show blurred outlines and have been partly absorbed.

There is an interesting assemblage of eruptive rocks near the mouth of the small river, where not alone the coarse granite and dark greenstone, but dikes of at least two kinds of granite, finer in grain and paler in color than the batholithic mass, penetrate the greenstone; a wide dike of diabase, probably Keweenawan, cuts the granite, and tiny dikes of felsite appear in the diabase itself. There are then eruptives of at least four ages, from Keewatin to post-Keweenawan within a space of 100 feet on the clean ice-smoothed and wave-washed shore. The contact of granite and the older rocks is clearly eruptive, with no blurring of boundaries or dragging out into gneissoid forms at the southern edge of the Laurentian batholith just described. Going north

Keewatin and granite, mouth of Red Paint river.

along the shore, however, the patches of greenstone in the granite appear to be more rolled out and elongated, the granite becomes gray, as if greenstone had been absorbed, and an indistinct gneissoid structure is noted.

The long peninsula of Livingstone point now intervenes, with a sheet of diabase hiding the older rocks for a mile and a half from its end. Rounding the point some Keewatin greenstone and breccia shows beneath the diabase for a short distance, but is covered again. Entering the bay Keewatin schist of a green black color appears on the islands, interleaved with thin seams of granite, and this intermixture continues as far as points near the mouth of Red Paint river, where the relationships were somewhat closely studied.

On certain islands near the river mouth the Keewatin consists of amphibolite porphyrite or greenstone and green schist, in every stage of intermixture with granitoid gneiss, which no longer has the appearance of eruptive granite; and no more instructive display of the mode of production of Laurentian gneiss or a "basal complex" could be desired. Unchanged masses of amphibolite an acre or two in area may be found on some of the islands, penetrated by small lighter colored dikes of more than one age. Near by the greenstone is brecciated, the sharp-edged blocks cemented by

thin sheets of granite. At other places both the greenstone and the granite dikes have been drawn out into long bands with a schistose structure having lighter and darker layers. Finally one finds them passing into rather coarse gneiss, banded with lighter and darker shades, but with no distinguishable greenstone or green schist left. This grayish gneiss is itself cut by dikes of red granite or of pegmatite, later effusions of the general magma.

At several points on the small islands *lit par lit* injection is beautifully illustrated, bands of green schist and granite alternating of every dimension down to a millimetre (one twenty-fifth of an inch) or less. On some surfaces the banding shows two shades of green along with the pink of the granite. Thin sections prove that the darker green bands are diorite schist, consisting of plagioclase and hornblende, the paler green bands

Sand spit, Lake Nipigon.

quartz-epidote rock, while the granitic bands consist of quartz, plagioclase, microcline and hornblende. All the minerals tend to be crushed and strained, perhaps because of later movements in the region after the granitoid gneiss had completely solidified.

In many places also the granitic materials have augen structures, with rows of pinkish crystals, all oval and tailed out at the ends, suggesting movement since solidification.

Frequently there are two stages of the process of interbanding, *e. g.*, in one case a band of coarse granitoid gneiss eight inches wide was seen enclosing a narrow band of dark green schist of equally coarse grain, and carrying off also fragments of very fine grained green material with thin seams of pink. Here the earlier injected masses had cooled and then been swept away by fresh granitoid magma welling up from beneath, of a more fluid kind, capable of dissolving and absorbing the basic materials of the Keewatin more completely.

Thin sections of the granite belonging to this laccolith show that it contains a large amount of plagioclase (oligoclase), and should perhaps be called grano-diorite rather than granite, though its flesh color is characteristic in most places. It is very quartzose, contains muscovite, as well as biotite and oligoclase, with orthoclase or microcline as the feldspars.

Dikes extending into the Keewatin are finer grained, sometimes flesh colored and sometimes gray. A thin section from a flesh colored dike has the same constituents as the main granite, though with less biotite and more muscovite. A thin section of a gray dike rock has a fine grained ground mass of the same minerals as the other, but with more biotite, including, however, phenocrysts of plagioclase, often Carlsbad twins.

The adjoining Keewatin schist consists of hornblende, plagioclase and a little magnetite, probably minerals rearranged from some basic eruptive like diabase.

The Nipigon or Keweenawan Formation

Introduction

Overlying the granites and gneisses of the Laurentian with the greenstones and schists of the Keewatin there are in many parts of the Nipigon region much later rocks, sediments and eruptive sheets which have been variously named. Logan in early days spoke of them as the "Upper Copper-Bearing Series," which he studied in detail on Thunder Bay and followed up to the mouth of Nipigon river.[4]

As seen near Thunder Bay this formation is sedimentary in the lower part, but has interstratified "trap" layers towards the top and is crowned by an enormous "trappean overflow," the whole resting on the Animikie or "Lower Copper-Bearing Series." The sediments are white and red sandstone or grits, conglomerates with jaspers, etc., reddish and white limestone, calcareous shales or indurated marl, and another sheet of red and white sandstone. Logan gives a total thickness of 830 feet up to the foot of the upper sandstone, whose thickness he does not estimate. The overlying trap is said to be 6,000 to 10,000 feet thick in some places; it is generally amygdaloidal, and sometimes has its surface covered with concentric wrinkles indicating flow as lava streams or sheets.

As the conglomerates contain pebbles and boulders of jasper like those of the underlying Animikie, there must have been a considerable break between the two formations; but the sills of diabase spreading between the sedimentary rocks of the Animikie and the Keweenawan are of the same age and character, no doubt representing parts of the Upper Keweenawan lavas which have not reached the surface.

Dr. Bell and Mr. Peter McKellar, his assistant, mapped and briefly noted the geology of the Nipigon region, including the east shore of the lake, about 40 years ago. The red sandstones were thought to resemble those of the Permian and Triassic of Nova Scotia, and it was suggested they might be of the same age.[5] In a later report Dr. Bell gives the name "Nipigon Series" to the "Upper Copper-Bearing Series" of the Nipigon region and apparently abandons the idea of their being a Permian or Triassic age.[6]

In 1894 Mr. W. McInnes gives a short account of the Nipigon formation along the Canadian Pacific railway near Nipigon Harbor, and makes the interesting suggestion that the lake lies in a trough carved in the Nipigon series and its associated traps, restoring an old basin in the Archean. He considers the Nipigon series equivalent to the Keweenawan, the name introduced south of lake Superior for the rocks of Keweenaw Point in Michigan.[7]

In 1898, Mr. D. B. Dowling mapped the islands in the lake, and traversed Sturgeon river and a chain of lakes to the south. He makes a further suggestion in regard to the basin, that it was due to the settling owing to the removal of the molten material of the trap sheets from beneath.[8]

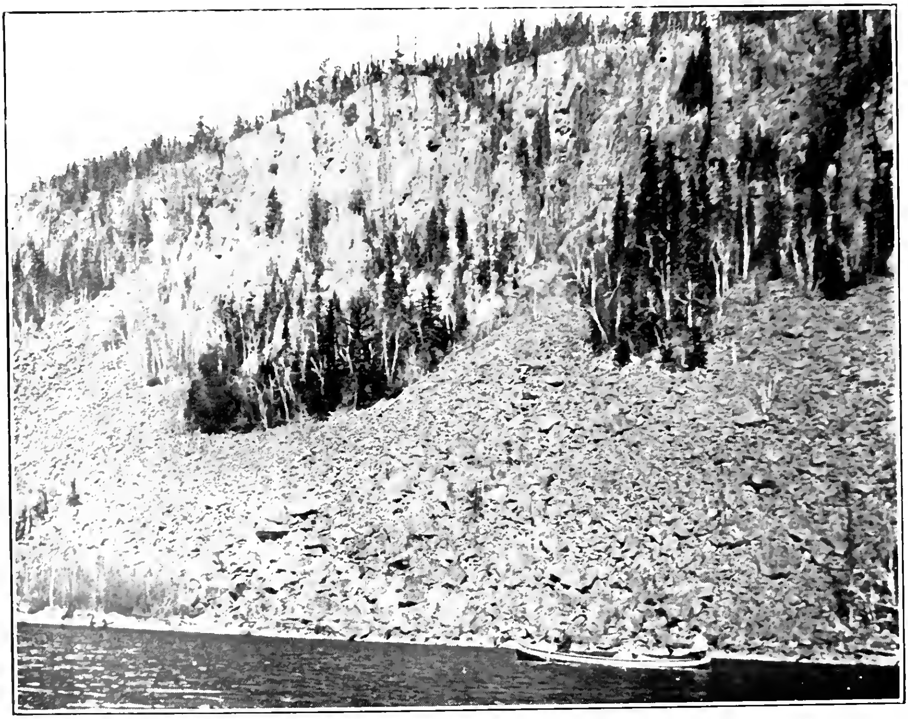
[4] Geology of Canada, 1863, pp. 70-79. [5] G.S.C. 1866-9, pp. 315-314.
[6] G.S.C. 1872-3, p. 106. [7] Ibid., 1894, Sum. Report A. pp. 19. etc. [8] Ibid., 1898, Sum. Report A. pp. 95, etc.

Finally Dr. W. A. Parks was sent by the Survey to complete the work on the northeast of lake Nipigon, so that a geological map of the whole district might be prepared.[9]

In spite of the fact that so many geologists have worked in the region, only summary reports have yet been published accompanied by sketchy maps without geological coloring.

Besides the members of the Survey, Messrs. Willmott and Flaherty have done economic work near lake Nipigon, especially east of Poplar Lodge and at the head waters of Red Paint river, with the object of locating iron ore deposits; but they have naturally paid little attention to rocks later than the Iron formation, such as the Nipigon series.

In the Report of the Bureau of Mines for 1906 observations of my own on some outcrops of the series are given incidentally. During the two summers spent there



Columnar diabase, Nipigon river.

materials have been collected for a somewhat more detailed account of these rocks as exposed along the railway, the river and the eastern shores of lake Nipigon. The name usually given to these sedimentary rocks and the associated diabases is Keweenawan, but at the numerous points where the sandstones, shales and limestones are lacking it is not very certain that this name really applies to the sheets of basic eruptive rock. In the Nipigon region they are apparently not amygdaloidal, but are chiefly laccolithic sills, very like the Logan sills, as Lawson has called them, in the Port Arthur district. Near Thunder Bay these sills occur in the Animikie series, but are, of course, later in age than the slates between whose layers they have spread out.

In the Nipigon region the sills are later than the Keweenawan sediments also, and form similar sills, but they may be of the same age as the lava sheets toward the top

[9] G.S.C., 1902, Sum. Report pp. 211-219.

of the Keweenawan, as found, for instance, on Michipicoten island. We may suppose that the surface volcanics, found in other parts in thick successions of amygdaloidal sheets, were thin here and have been eroded away, or were absent from the beginning. The idea of a "crowning overflow" forming the cap of all the hills must be given up, the sheets covering the hills having been injected between the sediment and then disclosed by the removal of the overlying softer rocks.

Physiographic Features

Every one is struck with the topographic features introduced by the sheets of "trap" or diabase, which gives flat topped hills or table mountains, with almost perpendicular walls formed of the rude columns into which the rock is divided by its vertical jointage. The surface of the sheet is often very flat, or gently undulating, and either horizontal or slightly tilted. The thickness of the sheets may reach 300 or 400 feet, so that almost unscaleable cliffs surround the hills, or make an abrupt end to gently inclined plains. At the foot of the cliffs a talus of blocks quarried by frost is always piled, often high enough to conceal the sheet of sedimentary rock which in many cases underlies the diabase.

The contrast is very marked between these flat topped, gray walled mountains and the Archean domes and ridges of pinkish granite and gneiss or green schists, having usually much gentler slopes and less regular forms. Often the diabase hills are isolated remnants surrounded by the more varied forms of the Laurentian and Keewatin rocks, from which the original covering of sediments and "trap" has been eroded, bringing to light once more the ancient topography, as noted by McInnes. Around lake Nipigon itself the sedimentary parts of the formation are very thin, and rise but little above the water or are not disclosed at all. Near Nipigon bay, along the shore of lake Superior, in many of the hills the lower part, sometimes to a height of 200 or 300 feet, consists of sandstone, limestone and shale usually brown or red in color, giving very striking scenery, red based hills topped with sombre gray. The old Hudson Bay post was called Red Rock, from the glowing color of the shales on the west shore of the bay.

Beside the flat topped diabase hills there are on the east shore of lake Nipigon ridges of very similar diabase, having hummocky and irregular tops and no well marked cliffs caused by vertical joints. One such ridge or range of hills runs several miles from northwest to southeast with a width of two or three miles between the Poplar Lodge iron claims and those of Wendigokan. These may be laccolithic masses, or, as has been suggested, gigantic dikes, eruptions probably of the same age as the sheets. Here the topography differs less from that of the surrounding Laurentian and Keewatin.

Faults in the Keweenawan

Logan and the later geologists have recognized that the region has been faulted into blocks which have been slightly tilted; and the fault planes, being lines of weakness, have suffered erosion faster than unbroken parts, so that the river channels are apt to follow the faults. This may be seen along the Nipigon river, where in some places steep walls of diabase rise on one side and low cliffs or hills of Laurentian on the other, the two sides of the river having totally different topographical features.

The actual plane of faulting on the large scale, forming the tilted blocks, is very seldom visible, having always been greatly shattered and attacked by weathering and erosion, so that it is in the lowest parts and buried under drift deposits. Faults on a small scale are however often seen, as on the cliffs a mile or two west of Kama, the next station on the Canadian Pacific railway east of Nipigon, where sediments and thin diabase sheets have been broken into blocks or slices and shifted two or three feet, so that a stratum that can be traced along the outcrop is divided into a number of fragments, all nearly horizontal but at different levels.

So far as observed all the faulting came later than the injection of the diabase sills, *i. e.*, in post-Keweenawan, probably Cambrian times; and may be accounted for by the settling of the beds after the removal of so much lava from beneath.

Relation of the Eruptives to the Sedimentary Rocks

It has already been mentioned that the Keweenawan diabase exists mainly as sheets which have spread out between the sedimentary rocks, and near lake Nipigon shows no amygdaloidal structure or ash or agglomerate beds, to suggest surface volcanic activity. If volcanoes once spread out sheets of lava in this region, as on Michipicoten island and Keweenaw point, the lavas and ash rocks have been destroyed. As in the Animikie the sheets cooled to form sills at a considerable depth, where the pressure prevented steam from expanding to produce the cavities which could later be filled with various minerals and form amygdules.

Since the thicker sheets make the tops of the hills, the softer rocks above having been removed, their contact with the overlying rocks is no longer to be seen, but the finer grain of the diabase, on the upper side indicates the cooling effect of their presence. In some cases curving lines of flow occur on the fine grained surface, as on Flat Rock portage near South Bay, and Logan describes and figures such markings from St. Ignace island, and looks on them as indicating the flow of lava streams.[10] Where there are no amygdaloidal layers or other indications of surface volcanic activity, these crescent-shaped wrinklings do not seem sufficient evidence of lava flow, and may be due simply to the dragging of the sluggish fluid as it spread beneath the overlying rock. Where the sheets are thin enough to show both surfaces with the sediments above and below, the diabase grows fine grained on each surface, and seems to harden and change the sedimentary rock. At the edge the two rocks blend and a paler gray band is formed by the fritting of shale or limestone. Some of the sills are only a few inches thick and often run out in feather edges.

While the sills generally keep to their level, there are cases where they ascend steeply from one level to another. About two miles west of Nipigon Station a thick sheet of diabase pushes up over the red shale at an angle of 40 degrees, crushing it and changing the color and texture of the shale, which is green and much harder, for ten or fifteen feet away. There are also places where the shale has been crumpled and contorted.

Immediately beneath some of the larger diabase sheets the limestone is often changed to marble, of a red or white color, some specimens being quite handsome, but so far as observed these beds are too thin to be of practical importance.

Keweenawan Sedimentary Rocks

Sandstone and Quartzite

Conglomerates have not been observed in the Nipigon region, though occurring not far to the west, on Thunder Bay. Coarse sandstones or quartzites are frequent, generally white or pale gray in color, but sometimes red or brown from oxide of iron between the grains. Half a mile west of Nipigon station a small railway cutting exposes a flat-lying bank of pinkish white sandstone, whose relationships to other rocks are concealed, but which is no doubt Keweenawan in age. It is a firm, medium grained sandstone with scarcely any hint of stratification, perhaps because the outcrop is not extensive. A thin section shows nearly pure quartz sand grains, with a very few feldspar grains, all usually well rounded and with dusty edges. The cement consists of a small amount of interstitial quartz. Except for its pale color, the stone would be excellent for building purposes.

Bands of pale gray sandstone or quartzite are found a mile or two west of Kama, near the foot of cliffs capped with diabase sheets. The beds are not very thick and pass into red-brown sandy shale. The rock is more compact than the one described above, and contains more of the feldspars. A thin section consists of about three-fourths quartz grains, and one-fourth of other materials often somewhat turbid in appearance, including orthoclase, microcline, and plagioclase and a certain amount of some car-

[10] G.C. 1863, p. 72.

bonate. There are also concretionary spherules, made up of microcrystalline silica and a carbonate. The quartz grains are often well rounded, and have been enlarged by a growth of clearer quartz till the individuals met and formed an interlocking mosaic.

White quartzite, very like that of the original Huronian north of lake Huron, occurs beneath the Keweenawan diabase south of Obabika bay, near the northeast corner of lake Nipigon. It is grayish white and very hard, and in thin sections proves to consist almost entirely of interlocking quartz. The original grains of sand contain many bands of minute bubble holes, and are rimmed by a little dusty material, while the new quartz, representing their outgrowth, is clear.

This quartzite has a more ancient look than the sandstones or semi-quartzites found near the shore of lake Superior to the south, which may be accounted for by the fact

Our party on eleventh portage, Red Paint river.

that a small dike of granite cuts the quartzite and the overlying diabase at this point, and that pegmatitic looking material penetrates it also at one or two places. If the diabase were absent one would be inclined to look on the quartzite as Huronian.

Shales and Slates

Shaly or slaty rocks are well developed in the Nipigon region north of lake Superior, but have not been noted on lake Nipigon itself. They are very variable in color, running from dark gray, almost black, to several tones of red and pale green.

A specimen taken from a cliff three or four miles west of Nipigon station is very dark gray, compact, not very slaty, but with a vague conchoidal fracture, and much resembles the Animikie slate near Port Arthur. A thin section proves to be exceedingly fine grained. Quartz in minute particles, scales of chlorite and probably also of sericite, and considerable amounts of dark opaque substance can be distinguished, the last probably some carbonaceous material, since slivers of the rock burn to a paler gray.

The ingredients are not evenly distributed, and there are oblong areas in which the dark substance is more thickly scattered.

A more common shale is brown red to purplish red in color, often spotted with small green spherules, or with patches and shreds of white, resembling shaly beds in the "Soo" sandstone at Sault Ste. Marie. This variety crumbles easily to small fragments when acted on by the weather. It has very little cleavage, but is distinctly banded parallel to the stratification. Some specimens effervesce a little with cold acid, but most are scarcely affected by it, showing that carbonate of lime is not an important ingredient. Under the microscope small particles of quartz and of a carbonate, probably dolomite, make up most of the sections, with a red brown matrix of iron ore. Some of the bits of quartz have crystal forms, but most are irregular splinters. The pale green patches are round, have no sharp edges against the ruddy parts, and seem to consist of the same materials without the iron oxide. A thin section from a somewhat purplish specimen shows a good deal of dirty looking indeterminable material between the quartz fragments, and much less of the dolomite. The white patches seem to consist partly of dolomite and partly of a scaly or fibrous mineral of uncertain character.

The green variety of shale is less extensively found than the red, and differs from it mainly in the absence of iron oxide. A thin section from a specimen altered by contact with a diabase sheet two miles west of Nipigon station is somewhat different in composition, containing much of a faintly polarizing scaly mineral, probably chlorite, and a good deal of dolomite. This rock passes in ten or twelve feet into ordinary red brown shale, and has apparently been formed from it by reduction of the sesquioxide of iron and the increased crystallization of chlorite.

Limestones and Dolomites

In the region studies limestones and dolomites occur in rather small quantities. In the outcrop four miles west of Nipigon station a band of gray dolomite two feet thick runs for a long distance, making a striking contrast with the red shaly rock above and below. The rock has been greatly crushed and recemented.

About six feet of fine grained marble, white with some reddish tints, is found at a bold promontory a few miles west of the Virgin islands, underlying a thick diabase sheet. The rock is handsome but is very much shattered, and its position beneath the diabase would make it difficult to quarry. This outcrop effervesces with cold acid, and so is limestone rather than dolomite. Thin sections show fine grained, closely interlocking calcite, with small amounts of some turbid substance. It is doubtful if any of the limestone or dolomite outcrops will be of value as furnishing building or ornamental stones, but material for lime burning may be obtained on a large enough scale for local purposes, in a region very deficient in that respect.

The Diabase of the Sills

The rock forming the sills or sheets which cap the hills so characteristic of the region is generally of a monotonous kind, medium grained dark gray, weathering to brownish tones, with a rude columnar structure. It regularly grows finer grained against the sediments, and never shows pillow or amygdaloidal structures. In general it is olivine diabase consisting of plagioclase (labradorite) to the extent of more than one half, brown or purplish brown augite about one third, olivine and magnetite in considerable quantities, a little biotite in some cases, and a few small prisms of apatite. The structure is generally distinctly ophitic, the lath-shaped feldspars projecting into the augite anhedra, which are often large enough to give a "mottle lustre" effect in hand specimens. The magnetite is generally in rather large masses, often including other minerals, as if it were one of the later substances to solidify.

Usually the rock is very fresh, though in some sections the olivine is partly or wholly turned to serpentine, and the augite has fringes of green secondary hornblende.

On the surfaces against the other rocks the diabase becomes much finer grained and is bluish black in color, weathering paler gray or buff. Thin sections show a quite different appearance from those of coarser varieties of the rock, having a distinctly porphyritic habit, with comparatively large crystals of plagioclase and a few of augite enclosed in a somewhat opaque ground mass and themselves enclosing remnants of glass. The ground mass is apparently a somewhat devitrified basic glass, through which are scattered many lath-shaped feldspars with ragged ends and often a dark core. In the brown turbid ground mass there are many black particles of magnetite.

Where the diabase cooled against dolomitic shale the usual red of the shale has been destroyed, the sesquioxide of iron being reduced. The black of the porphyritic glass becomes gray, perhaps by absorbing constituents of the shale, and the ground mass is less transparent, but there are still laths of feldspar contained in it, of the same kind and as thickly scattered as in darker parts of the rock.

The diabase presents also coarse grained varieties, having little ophitic structure or none at all, transitions to gabbro, but with the same mineral constituents. Often the weathering out of olivine leaves the surface pitted, and rock of the kind on the promontory west of the southeast bay of lake Nipigon and elsewhere is rapidly crumbling into a coarse sand of a green gray color. No very sharp line can be drawn between diabase and gabbro in the region, since both consist of plagioclase, augite, olivine and magnetite, the only difference being the lath or plate-like character of the feldspars in the diabase as contrasted with feldspars having diameters more nearly equal in the three crystallographic directions in gabbro.

Basic Phases of the Keweenawan Eruptive

Closely connected with the olivine diabase sheets described above, there are more basic olivine rocks, probably differentiation products of the same magma. Rocks of this kind are found at Virgin falls, near the outlet of lake Nipigon; and consist chiefly of augite and olivine in about equal quantities. Wedged into corners there is some plagioclase, and magnetite and brown biotite occur also in subordinate proportions. The olivine has good crystal forms, and with some of the magnetite came first in order of crystallization. The rock is more nearly a picrite than a gabbro.

Not far away from the point where this specimen was taken, below the first of the Virgin falls, a coarse variety of the basic eruptive has in part undergone deep seated change into actinolite and garnet.

A still more basic variety is found on an island just south of Halfway point, on the east shore of lake Nipigon, a dark gray rock of coarse texture with a deeply pitted surface. Thin sections are like those from Virgin falls, but with less plagioclase, about one-tenth of the whole, and more mica, deep brown and highly pleochroic. In this rock the olivine is badly weathered, serpentine running along all the fissures with patches of the unchanged mineral between.

The very basic phases of the olivine diabase are not wide spread, having been found only at the two points mentioned.

The dikes and bosses of diabase or gabbro found penetrating the older rocks, Laurentian and Keewatin, are of various kinds, some like the Keweenawan sills and probably filling the channels through which the diabase ascended, others without olivine and containing a little quartz, probably of an origin distinct from the sills. These outcrops are referred to in the account of the iron ranges and their associated rocks.

Post-Keweenawan Dike Rocks

At several points small dikes of a fine grained granitic-looking rock were found in the diabase sills, the first being seen on Flat Rock portage near the south bay of lake Nipigon, others being found later on Livingstone point and Obabikon point. At Flat Rock there are several very narrow dikes of the granitoid rock, the largest a foot

wide, occupying short fissures in the diabase or following the boundaries of a rude columnar parting. The rock is fine grained, and has the usual flesh color of granite. The largest dike observed has a width of 30 inches and cuts quartzite and the overlying diabase on a promontory a mile southeast of Ombabika narrows. It could be followed 100 yards inland; and in the quartzite near by there were a few narrow interlacings of coarser granitic looking material. Thin sections show the rock to be grano-diorite rather than granite, in spite of the pink color, since the feldspars are mainly plagioclase, the amount of orthoclase being small. Quartz is present to the extent of about one-quarter, partly in rude pegmatitic forms, and a little hornblende and brown biotite occur in one specimen, while decomposition products representing some ferro-magnesian mineral are found in small amounts in the other. The plagioclase, which has the

Muskeg, Height of Land, Red Paint river.

characters of oligiclase, commonly shows fairly well developed crystal forms of clear mineral in the centre, with an irregular outgrowth of weathered feldspar round them. These little dikes of grano-diorite occur frequently, and seem rather widely spread from one end of the lake to the other, being found in most of the sheets of diabase which we had an opportunity to study on well exposed surfaces. None have been seen in the other rocks of the region, perhaps because they have not been looked for; and it seems as if they were bound up with the Keweenawan eruptives, perhaps as a last differentiation of the original magma, penetrating cracks and wider fissures of the cooling diabase.

The grano-diorite is, of course, later than the diabase sills, which probably reached their present positions at the very end of the Keweenawan, while lava and ashes were being distributed on the top of the Keweenawan sediments. These acid dikes are, therefore, of Cambrian or even later age, and the most recent solid rocks known in the region.

Geology of Nipigon River

Although so many geologists have gone up Nipigon river, there is no detailed account of the geology of its shores. As the river is visited by hundreds of tourists and fishermen every year, it seems worth while to point out roughly the distribution of the rocks as observed during our four journeys up and down. As we were always *en route* to points beyond, no time was permitted for elaborate work on the river, yet the main points were noted, and some of the portages were carefully studied.

Where the upward journey begins on lake Helen, sand plains representing an old water level of lake Angonquin (an ancient glacial lake) cover the solid rock, with a tree-covered moraine between them and Nipigon station. Beyond the east shore of lake Helen one sees Laurentian country with a hilly, rolling surface, and a few higher flat topped hills with steep cliffs caused by remnants of Keweenawan diabase sheets. Turning through a marshy delta after five miles on the lake, one enters Nipigon river, with low banks of stratified clay and sand, partly cultivated by the Indians.

At camp Alexander, the first portage, granite comes up beneath the old lake silt on the southeast shore and a cliff of diabase rises on the other side of the rapid. The portage road runs first over lake terraces of sand and gravel, afterwards over bouldery moraines, and no solid rock is seen until one reaches the upper end, where the river is once more canoeable. The rapids begin over red granite and fine gray gneiss, like the Couchiching of Rainy lake, but half a mile down, a ridge of coarse diabase rests on the granite for 100 yards.

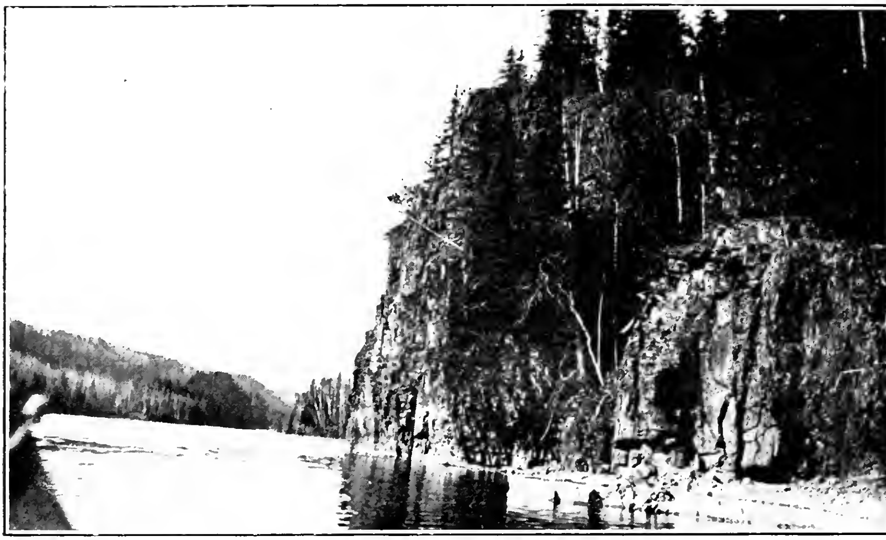
Probably the pre-glacial channel of the river was to the west of the present one, the morainic material rising as hills on the portage road and to the northwest, having been piled up in such a way as to block the valley and force the water in to the present channel.

On the east side of the river above the rapids there are low hills of red granite, and also a small patch on the west side under the moraine. Above the narrows the east side shows mainly gray or green Keewatin schist, steeply tilted and penetrated by red granite and pegmatite dikes, some of which contain large black crystals of tourmaline, probably dikes from the granite region to the south. On the west side diabase rises, and a mile south of Split rock portage a sill of diabase covers the Archean on both sides of the river, rising to the east as splendid vertical cliffs. The nearest cliff has a height of 450 feet above the water, talus covering the lower part, and a diabase hill half a mile inland is much higher. The rock which "splits" the rapids is a huge mass of the same diabase sheet.

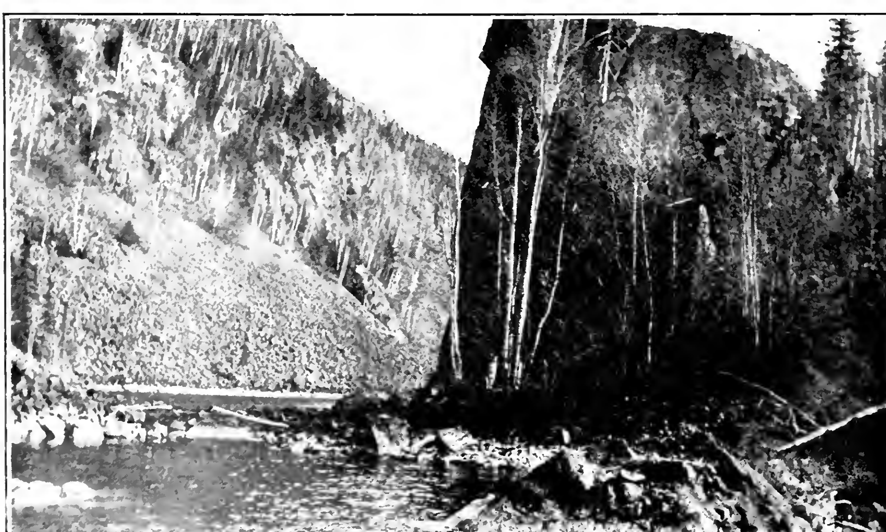
From the Split rock portage to Island portage diabase rises on each side, but the river has cut through it to the underlying Keewatin. The portage leads over a small low island of nearly vertical gneiss, gray and fine grained, with a strike of 40 degrees, closely resembling the Couchiching gneiss of Rainy lake.

Soon after this Pine portage is reached, the river having low shores at this point with no cliffs of diabase. At the foot of Pine portage there is greenish gneiss or mica schist with garnets, but the road passes overy bouldery morainic ridges to the upper end, where coarse, black diabase rises above the quiet waters of the river on each side. Cliffs of diabase wall in the channel from this to Little Flat Rock portage, which crosses a low nearly flat sill of the same rock. Diabase extends all the way from this portage to the next at Victoria rapids, and seems to reach as a low flat surface past Hannah lake on the west to the shore of the South bay of lake Nipigon.

From this point one may reach lake Nipigon in three ways: by lake Hannah and Big Flat Rock portage to South bay; or straight up the river to Virgin falls, where the portage runs first over stony moraine, then over flat eruptive sheets more basic than diabase; or one may turn to the east over a bouldery portage to a pond, through another pond and then cross a portage to a bay of lake Nipigon above Virgin falls, all over morainic materials. It is probable that this series of ponds represents an old outlet of the lake, blocked by moraines left by the last ice sheet.



Split Rock, Nipigon river.

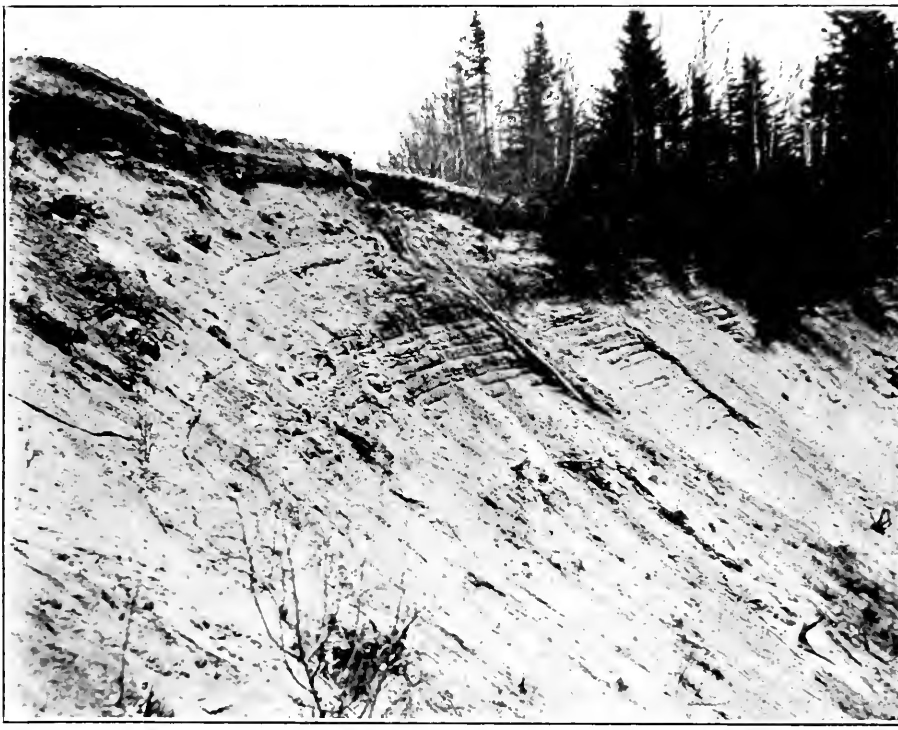


Split Rock, Nipigon river.

Pleistocene Geology

Old Lake Deposits

In last year's report brief references were made to the Pleistocene deposits of the Poplar lodge and Wendigokan areas[11] which are covered to the extent of about one-third by sand plains, old lake deposits formed probably in a great northern bay of lake Warren; and the observed levels of the plains were given, reaching from 860 to 1,020 feet above sea level. The lowest sand plains rise only a few feet above lake Nipigon which has an elevation of 852 feet.



Stratified beach deposits, Nipigon river.

Our past summer's work has greatly extended the known area of these old lake deposits, which reach as far as Battle Island lake, more than 30 miles east of the shore of lake Nipigon. Here we still have the usual sand plains rising about 20 or 30 feet above the water of the lake, which was roughly determined by hand level and estimation of the falls and rapids on Sturgeon river as 1,044 feet. From this the sand plains would stand at 1,060 or 1,070 feet above sea level. How much farther they extend inland is not known.

In some cases boulder clay may be seen at the bottom of sections cut by Sturgeon river through the drift deposits, rising a few feet above the water, then well stratified silt, sometimes 100 feet thick, followed by sand and coarser materials forming the top of the series of deposits.

[11] Bur. Mines, Vol. XVI., pp. 135 and 147-8.

In one section above the first falls on Sturgeon river there are 73 feet of silt followed by a layer with angular boulders, like till, as if the silt were interglacial, but the slipping of materials on the cliff above made the relations somewhat uncertain. Above the bouldery bed was stratified sand reaching 90 feet above the river or 994 feet above the sea. On Sand lake, much higher up the river, whitish silty sand was found for a few feet above water, followed by sand, with a level surface about 1,060 feet above the sea.

In many places the sand plains are uneven in surface, with depressions and small ridges or low gently rolling hills, perhaps representing the work of currents on a delta or in some cases dunes caused by wind work.

Most of the sand plains have the look of delta deposits, probably formed by a post-glacial Sturgeon river coming into a lake standing much higher than at present in early stages, but gradually sinking toward the present level of Nipigon. Deposits

Glaciated rocks south of Poplar Lodge.

of the same kind are now in process of formation at the mouth of Sturgeon river, varying and shifting in different seasons by the swinging of the river channel at its outlet. Smaller streams, like Sand creek at Poplar lodge, are doing similar work on a corresponding scale. The sinking of the level of lake Warren and its successors seems to have been stepwise, to judge by the succession of terraces.

How far north the stratified lake sands extend is not yet determined, but they are found well developed at the first falls on Red Paint river a few miles above its mouth, where the portage trail crosses a flat sand plain about 100 feet above the river below the falls, which is perhaps a foot or two above lake Nipigon. Beyond this to the northeast no well defined old water levels were observed as far as the watershed between lake Nipigon and Hudson bay.

Some low sand tracts have been noted along the shore of lake Nipigon beyond Red Paint river, but none rising more than a few feet, and it is doubtful if the higher beaches extend quite to the northeast side of the lake, where the drift consists of morainic materials little modified by water action.

Glacial Deposits

Toward the southern end of lake Nipigon from Sturgeon river towards Virgin falls, most of the low ground is hidden by sand plains and muskegs, as mentioned above, and typical morainic deposits are not often seen. Along Nipigon river, however, characteristic moraines occur as stony ridges at several places, and appear to have played a large part in turning the river out of its ancient channel, thus producing rapids.

Inland from the mouth of Sturgeon river several of its rapids are over boulders derived no doubt from boulder clay, and, as noted by Mr. Moore, moraines occur near Lake Wendigokan, but the most striking examples of glacial deposits are found near Trap lake, where kame ridges, eskers and bouldery hills are found. To the south one finds sandy till with sub-angular stones where fallen trees have upturned the soil, and much of the surface is covered with low ridges or hills, probably morainic.

The water shed northeast of the head of Red Paint river consists largely of moraine country, gravelly hills and kettle-shaped valleys, often enclosing lakes, occurring over many square miles, probably deposited at the margin of the ice where a great glacial lake confronted it toward the southwest.

Very bouldery morainic hills may be seen at Revillon post on the northeast side of Ombabika bay also.

Striated Rock Surfaces

Striated rock surfaces are quite widely found along the east shore of lake Nipigon, where the waves are just washing away the drift from the underlying rock. Inland in most cases the rocks are too much weathered and lichen-covered to show them, but strippings on the Iron ranges often disclose them. In the previous year striae running from north 60 degrees to 70 degrees were found near Poplar Lodge, and during the past summer many other ice smoothed and scratched surfaces were seen, in some cases showing two sets of striations, an older one displayed only in hollows or sheltered spots, and a newer one better preserved and more widely spread. Directions of striation were determined at a few points, as follows:

Shore of lake Nipigon north of Sturgeon river	45	degrees
Portage between Pasha and Ida lakes	60	"
River mouth south of Humboldt peninsula	80	"
Mouth of Red Paint river	85– 95	"
Mouth of Ombabika bay (older)	10– 35	"
Mouth of Ombabika bay (younger)	70–100	"

II.—IRON RANGES EAST OF LAKE NIPIGON

THE ONAMAN IRON RANGES

BY E S MOORE

Introductory

The writer was instructed by Mr. T. W. Gibson, Deputy Minister of Mines, to conduct a geological exploration of the Iron ranges around the head waters of Red Paint river. After assisting Dr. Coleman in finishing the work begun during the summer of 1906 on the Iron ranges of the Sturgeon River region, the writer proceeded to this new field and began work there on July 29th, but in September was compelled by bad weather to leave the field before the survey of the ranges was complete. The autumn snows and rains came early, and on the return journey heavy gales accompanied by sleet and snow were encountered on lake Nipigon, causing considerable delay in reaching my destination

In the field the writer was ably assisted by W. F. Green, B.A., fellow in Toronto University, who in every respect proved to be efficient in his work. Besides Mr. Green and the writer, there were in the party two very faithful Cree Indians, John and Henry Jeffries, of Moose Factory, and for a short time an Ojibway Indian, who proved unsatisfactory and was soon discharged.

Until quite recently, little was known concerning the geology of the district surrounding the head waters of the Red Paint. References had been made to its resources in some of the Canadian Geological Survey reports, but geologists had not done any detailed work there. Dr. W. A. Parks mentions in a summary report[1] that some claims containing deposits of limonite and ochreous hematite in sugary quartz seams running parallel to the inclosing schists had been staked by Andrew Green on Red Paint lake, the source of the south branch of Red Paint river. He says further that though jasper had been reported from the Red Paint river, neither the Algoma Commercial Company nor the Flaherty syndicate had located it.

Some prospecting had been done by the Algoma Commercial Company on the lower parts of the Red Paint river during the time that company was so actively engaged in exploration work in the Nipigon region and a few claims were surveyed. These claims lie along the stream near the ninth or "Red" portage about 21 miles from the river's mouth, but they were never of any commercial importance.

When the Transcontinental railway survey parties began work through northern Ontario, about five years ago, the Red Paint river became one of the highways for the transportation of mail and supplies, not only for the railway surveyors, but for a number of prospectors who entered the new region. The most energetic prospecting was done during the summer of 1906 when a considerable Iron range was located by men in the employ of Mr. R. H. Flaherty, and their strikes encouraged other prospectors to enter the field, but the majority of the latter were unsuccessful. During the following summer while our examination of the ranges was in progress Mr. Flaherty did diamond drilling on his claims. The complete drilling outfit was transported up the Red Paint and down Johnson creek a distance of about 55 miles, by use of canoes and packstraps, a feat which is probably unique in the history of mining in Ontario, if not in that of Canada. During the same season a range was located farther south, which appears to be the most extensive yet found in the region.

The writer has applied the term Onaman to the Iron ranges in the area explored because of a desire to have some euphonious and appropriate name for them, and

[1] Sum. Rep. Geo. Sur. 1902-3, pp. 213-222 A.

because of the difficulty of applying any other local name without danger of its being misleading. The word Onaman is the Indian name for Red Paint, and the term seems to be appropriate for all the ranges discussed in this report, and for those which in the future may be found in their vicinity.

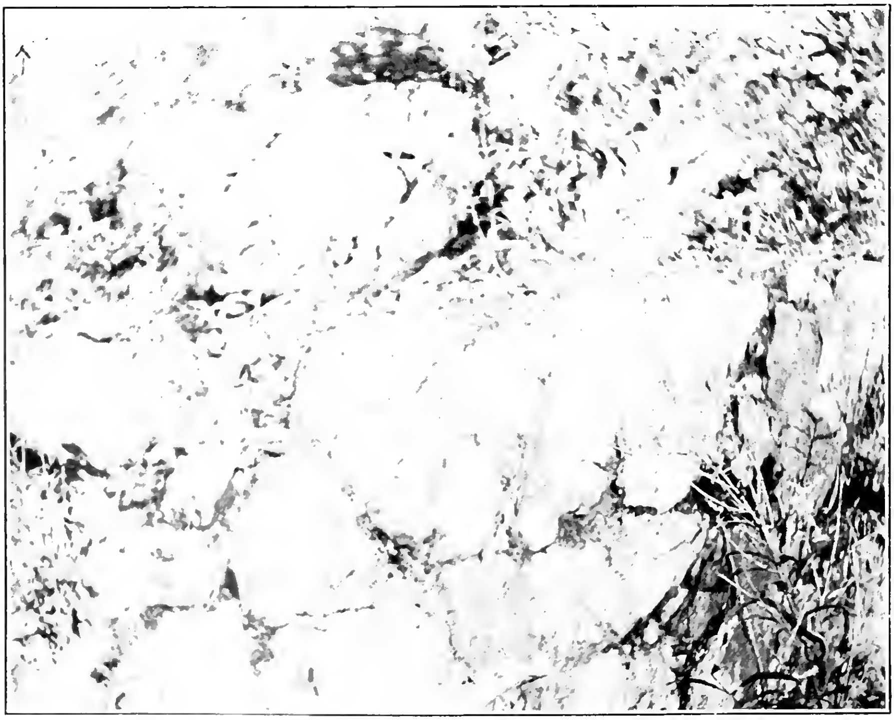
As in previous seasons, many favors were received from those who were met in the field, and this opportunity is taken of acknowledging them. Special thanks are due to Mr. P. A. Leitch for assisting us in various ways, and to Mr. R. H. Flaherty who placed all available information in regard to his work in the region, at our disposal. In connection with the preparation of this report, the writer is indebted to Dr. A. P. Coleman of Toronto and Professor Iddings of Chicago University for the counsel they have so generously given him.

Flaherty's diamond drill, Height of Land.

Geographical Position of the Iron Ranges

The Onaman Iron ranges occur in the vicinity of the Height of Land, one of the great continental divides, near the head waters of Johnson creek and Red Paint river. The area included in the Iron range district so far explored is between latitude 50° and 50° 30' and between longitude 87° 10' and 87° 45'. To reach the region it is necessary to make by canoe a journey of about 50 miles in a general northeast direction from the mouth of the Red Paint river, which enters Humboldt bay, the northeastern expansion of lake Nipigon. In time of high water this stream is easily navigated with canoes, but it becomes very low in the summer, and travelling is difficult, especially in the upper portion of the river where the stream is very crooked. Although there are twelve portages, the longest, which is around a long rapid about six miles above the mouth of the stream, is only two-thirds of a mile in length but has at its lower end a troublesome hill rising rather abruptly about 75 feet above the river. The other portages vary from less than half a mile to a few yards in length,

Second portage, Red Paint river.



Agglomerate, twelfth portage Red Paint river.

and are all well cut out. To cross the Height of Land requires a portage of about one and one-quarter miles over one of the best trails found anywhere in the country.

Although some important sand banks are seen on the lower parts of the stream, in passing up the Red Paint, one is impressed by the lack of the definite and high banks so characteristic of the Sturgeon river farther south, by the absence of high hills of any kind, and the prevalence of large swamps on either hand. A great deal of the rock along the stream is granite, and the knolls of this rock rising above the surface of the swamp give the typical Laurentian country. Several bands of Keewatin rocks are seen. The first of these occurs at the first, second and third portages, and is responsible for the rapids at these places. The next is at the ninth or "Red" portage, where a little Iron formation occurs, and the third one begins near the lower end of Oboshegegon (Narrow) lake, and extends along Whitefish lake and "Crooked creek" to the Height of Land. The remainder of the rock along the river is granite and diorite, chiefly the former, and belongs to the Laurentian system.

A number of lakes occur on the river. The largest of these, lake Oboshegegon, is about six miles in length and as its Indian name indicates is narrow and swampy. The upper lakes are rather shallow, and have hard clay or marshy bottoms.

Surveys

As no township or lot lines had been run in the region one of the survey lines of the Transcontinental Railway was made use of and was found of great service in forming a base to which our work could be tied, for purposes of a geological map. It was necessary to procure all the materials for the map by pacing compass lines, and this proved a difficult task on account of the bad brulé on the high lands, the wet swamps where the land was low, and the presence of some magnetite over many parts of the area, necessitating the frequent use of the dial compass during a season predominantly wet and cloudy. It is matter for regret that at the time of writing the final survey of the railway line cannot be obtained and placed on the map to accompany this report. The claim lines which are mapped are only those run by the prospectors, and though usually well run for a region in which local attraction is so troublesome, they should not be regarded as surveyors' lines.

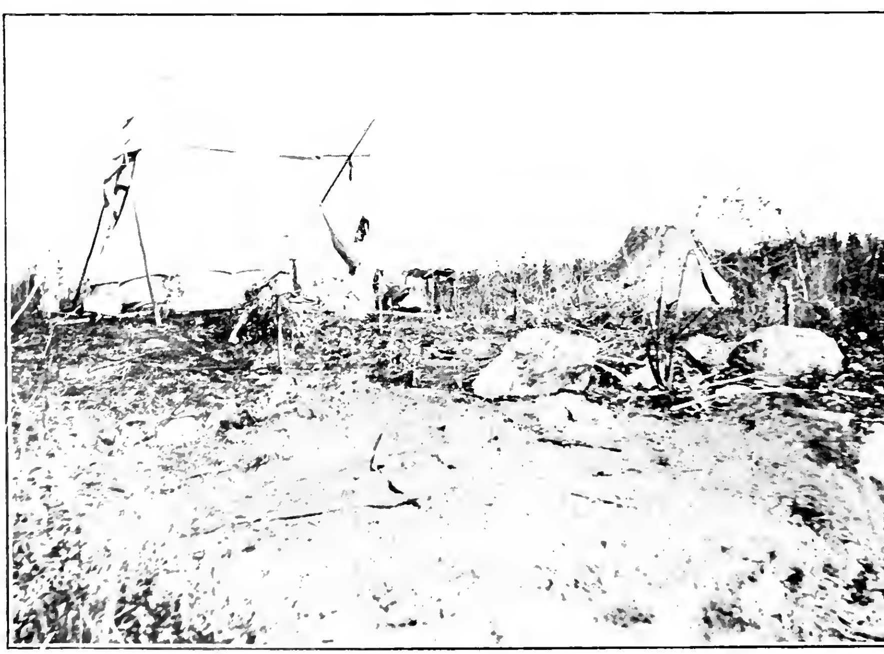
Soil and Vegetation

Much of the land in the region has been burnt over at different times, leaving the larger part of it covered by a tangled mass of dead jack-pine and spruce. Some parts of the burnt area, especially the hills of drift, are now covered by a very dense undergrowth of spruce, jack-pine and poplar which adds to the difficulties of travel, but the burning of the moss and other vegetation from the rocks has greatly facilitated the ease with which these can be examined by the prospector or geologist. During the summer of 1906, which was very dry, great bush fires raged along Johnson creek, burning nearly everything combustible from the surface of the ground and leaving the hills of drift which occur there almost as bare as a cultivated field.

The land which has not been burned is covered with swamps and muskegs. The timber of these swamps is mostly small, and much of it scrubby cedar, spruce, balsam and tamarac, almost all of it not large enough for anything but ties or pulpwood. Along the lower stretches of the Red Paint river, however, chiefly between its mouth and the second portage, there is some good spruce and tamarac timber, which will in time be utilized for lumber and other purposes. White birch is very common on the morainic hills of the unburned areas. No red or white pine was seen in this district.

It is said that the great clay belt of northern Ontario extends almost to the Height of Land in this region, and this is probably the case, as the hills here gradually give place toward the east to great flat areas covered by muskegs and

Typical "brulé," Height of Land, Red Paint river.



Our camp in burnt region, Johnson creek.

swamps over which the new railway line will have many miles of straight and almost level track. Although some of the flats along Johnson creek are sandy, and the hard stratified clay is found not far below the surface, there are many acres of land capable of growing good crops, as the soil on these is a clay loam. Considerable land along the lower reaches of the Red Paint would also be suitable for agricultural purposes, and there is little doubt that with a railway through this region, the land will some day be producing some kinds of crops and be capable of supporting to a large extent a mining population, if the country produces mineral wealth. The greatest drawback to the agricultural prospects of this northern region are the late spring and early autumn frosts, but if the land were cultivated these would become less

Beaver house, Black river.

severe than they are at present, just as they have been mitigated in many other cultivated regions. The long days with so much sunshine permit rapid growth, and small fruits are abundant. Wild strawberries grow on the clay flats, and blueberries are plentiful on the rocky and sandy ridges.

Fauna

The beaver is the most interesting animal in the region, and is fairly common. These animals are so bold that some of them attempted on one occasion to dam the Red Paint at the outlet of Holliday lake where canoes frequently passed to and fro. Some moose were seen, and caribou frequent the woods, especially during the colder seasons, but there is a marked scarcity of red deer in the whole of the Nipigon region east of the lake. Partridge and grouse are plentiful, the latter appearing in largest numbers in the spring, about the time the snow begins to disappear. The

region is looked upon as a favorable one for trappers of small fur-bearing animals, and many marten, fisher and muskrat are taken during the winter. Fish are not so plentiful nor so fine as they are farther south, but plenty of pike are found in the streams and lakes. Some pickerel may be taken from the lakes, and a few brook trout have been caught in Johnson creek.

Topography

According to information obtained from the bench marks along the railway location there is a difference in level of 191 feet between the mouth and head waters of the Red Paint river. The stream has an average fall of about four feet per mile, and this is concentrated in a number of falls and rapids which vary in height from two to fifty-four feet, but the amount of water in the stream at some seasons is too small to make it a valuable one for power purposes.

The continental divide in this region is not conspicuous as a ridge, and in some places there is almost continual swamp across it with streams issuing westward on one side and eastward on the other, the water of the former reaching the Atlantic by way of the great lakes, and that of the latter going to James bay by the Albany river. The highest point on the portage crossing the divide has an altitude of 1,070 feet, but a little farther northwest some of the gravel hills form a ridge with an altitude of 1,150 feet, and similar hills extend eastward along Johnson creek at an elevation of 1,100 feet above sea level.

Taking the country as a whole, there are no great variations in level. No matter in what direction one goes he encounters no great hills, and finds that there is not anywhere a difference of more than about 175 feet in elevation, between the lowest stream valleys and highest hills. The region has the appearance characteristic of the great Archean peneplain of northern Ontario, which has been formed by the reduction to a general level of most of the once prominent hills, leaving a few monadocks where harder formations rise above the surrounding lands.

The large deposits of terminal moraine along Johnson creek with the small outwash plains, undrained depressions and kettle lakes form rather conspicuous topographic features. There is a difference in elevation between the top of some of these drift hills and the undrained depressions lying in them of about 75 feet, and as the hills have been so thoroughly burned off by the bush fires they stand out as prominent features which can be seen for many miles.

Johnson or Old Log creek, a sluggish stream meandering through a marshy plain forms part of the canoe route to the east. The amount of water flowing in it varies greatly in different seasons. During the summer of 1906 it was a small creek along which it was difficult to pass with canoes, but in 1907 it was swollen from bank to bank and formed a good sized river. Along its lower stretches it flows mostly through muskeg, and at all seasons there is plenty of water for canoes.

Classification of the Rocks

The rocks of the region may be tabulated thus:

PLEISTOCENE	Drift, lacustrine sands and clays.	
PRE-CAMBRIAN	Keweenawan (?)—Basic eruptives: gabbro and diabase.	
	Lower Huronian (?)—Conglomerate and arkose.	
	Laurentian—Granite, gneiss and diorite.	
	Keewatin	Iron formation: slates, jaspilytes, banded silica and magnetite.
		Porphyries (felsites) and tuffs.
		Greenstone and green schists.

Although the rocks are classified in this order, they are not so arranged without uncertainty as to the age of some of them.

The greenstones are typically Keewatin and are unusually well developed in this region, while some of the porphyries are hard to locate in the age classification, because

they have been so intimately folded into the Iron ranges that they appear either as dikes or other masses cutting the Iron formation, or as extrusions which were interbedded with it. There are some rather basic dikes cutting the Iron formation on the Height of Land claims, but these have not been connected with any other rock masses of the district. The greater part of the porphyries are true rhyolites or surface lava flows, and there is little doubt about their being in most cases older than the Iron formation. This formation is similar to that in other regions where the Iron ranges are of Keewatin age and marks the upper horizon of this system.

The Laurentian granite and gneiss are common on the lower part of the Red Paint, and are reported from three sides of the Iron range district, but they are scarce within the region mapped. The diorite is placed with the Laurentian rocks, because the small mass found seemed to grade into granite and to be a contact phase of that rock.

There is no reason for placing the basic eruptives in the Keweenawan, except some resemblances to other Keweenawan rocks so well developed in the Nipigon region. There are no younger rocks associated with them by means of which their age can be determined.

The Iron Formation

There are two distinct Iron ranges and some scattered outcrops of the Iron formation in this region.

One of these ranges extends from the twelfth portage on the Red Paint river eastward across the Height of Land and down Johnson creek for a distance of about six miles. The range is not represented by continuous outcrops, and the strike of the formation varies in different places on account of irregularities in the folding of the sedimentary rocks caused by the massive igneous rocks associated with them. These massive igneous rocks of the Keewatin system are very prominent here, while the green schists, slates and pyroclastic rocks are not nearly so well developed as they are in the Sturgeon river or Michipicoten region.

On account of this predominance of igneous rock there are not long stretches of synclines and truncated anticlines with uniform strike, but a more broken and irregular arrangement of the folds in the sediments, and the latter now remain where folded into the hollows between prominences of igneous rock. Since the Iron formation lacks the great troughs formed by folding of thick strata of sedimentary rocks, it will probably prove to be shallower here than it is in these other regions mentioned where schistose and sedimentary rocks are abundant. There seems to be one syncline extending along the north side of the range on the Miller claims. The presence of this syncline is shown by the dip of the rock in these places and the conglomerate lying in the trough. The trough is bottomed mostly by igneous rock, as shown by the felsite dipping under the range along the south side and the greenstone along the north side. If any ore is found in this range it may be looked for in this syncline and a short distance north of the southern edge of the range. The folding and crumpling of the Iron formation is very acute in some places, and definite faulting has occurred in one part of the range.

The other range occurs between two and three miles south of the one described and runs nearly parallel to it. This range has not been traced to its limits, but it is exposed for about two miles and then runs into swamp, where its extension can be followed by means of the dip needle. It has many of the characteristics of the range to the north but appears to be more free from country rock.

The country rock of both ranges is chiefly altered quartz porphyry or orthoclase porphyry, and it is often intricately folded into the Iron formation. The rocks and iron-bearing minerals of the formation are slate, green schists, jaspilyte, specular hematite, magnetite and silica.

Besides the two ranges mentioned, there are some rather isolated outcrops of no commercial importance, such as those at the "Red" portage and those on lake St. Marie.

The Maple Leaf Claims

A short distance south of the eastern end of Holliday lake there are two chains which comprise the Maple Leaf group. The Iron formation in these claims is not so important as in some of the others, as the bands are narrow and much mixed with schist. The country rock is mostly a schistose felsite which was originally a quartz porphyry and has become almost unrecognisable by metamorphism. Some

Stripping on Iron range, Height of Land Red Paint, river.

of the felsite strongly resembles a conglomerate on the weathered surface, because of its brecciated structure which is emphasized by weathering. Besides the altered porphyries, there are some green schists associated with the range, and these are partly meta-igneous rocks and probably partly metamorphosed pyro- and auto-clastics.

Height of Land Claims

In this group there are five claims extending across the Height of Land, and the Iron formation outcrops on four of them. Considerable stripping and trenching has been done, so that the range is well exposed in several places, and in one exposure it reaches a maximum width of 175 paces, but in this width there is included a good deal of schist.

The strike of the rocks is nearly east and west with a gradual change to about 70° near the eastern end. They dip at a high angle northward.

The iron-bearing rocks and minerals here are bright red well banded jaspilyte, magnetite and specular hematite.

The rock along the south side of the range is a slaty chloritic schist, and there is also associated with it some orthoclase porphyry, which seems to have been folded into it in a complex manner. On the north side green schist is followed by an arkose, which is probably related to the conglomerate exposed farther east. The arkose and green schist are exposed for only a short distance before running under a large mass of drift, and the Iron range disappears in drift and swamp at either end.

There are two dikes cutting the Iron formation on the middle claim of this group. The widest of these is about three feet in width, and cuts slightly across the strike of the jaspilyte while the other one cuts it at nearly 45°. Both dikes are composed of basic rock so altered that they could not be identified. The presence of dikes in an Iron formation is an important feature, as they have played a large part in the formation of the ore bodies in Minnesota by forming basins for the reception of the concentrated ores, but in this case there is no evidence that concentration has occurred.

The Winter Camp Claims

The Iron range disappears under swamp near the east end of the Height of Land portage, and reappears almost two miles farther east. Just north of the small lakes on Johnson creek there are four claims on all of which the Iron formation outcrops. As there is some magnetic attraction in the swamp along the intervening space, it is pretty certain that some of the formation is buried under the drift.

The range on these claims is split by a long greenstone mass running parallel to the general strike of the iron range rocks which is here about 60°. The relations between the greenstone and Iron formation have been brought about by strike faults occurring along either side of the greenstone mass, which was in each case on the upthrow side of the fault. The presence of these faults is shown by the slickensided surface which may be seen in a hand specimen, being unusually well preserved on the hard jasper, by the greatly shattered condition of the jasper, and the abrupt transition from the Iron formation to the greenstone. It may be noted that in the regions of Keewatin rocks there are not, under normal conditions, sharp transitions from the Iron formation to the massive greenstone. This condition is due either to the fact that some other rocks have always been deposited on the greenstone before the jasper was formed, or that where the jasper lay directly on the greenstone the latter weathered in such a way that the former was easily removed by erosion.

The faulting is evidently much more recent than the great folding which included the Iron formation, because when the latter occurred this formation must have been buried deeply, otherwise the brittle jasper would never have assumed symmetrical folds but would have been shattered, as it is in the outcrop where the faults have occurred.

The fault plane of the northwest fault is apparently nearly vertical, as the contact has been shifted laterally very little. The drill hole which was put down in this outcrop shows that the dip of the plane must be at least as much as 65°, because a hole 351 feet deep at an angle 60° failed to reach the greenstone where the width of the jasper on the surface is about 300 feet. The dip of the fault plane being unknown, it is impossible to estimate even approximately the depth to which the Iron formation may extend beneath the drill holes, but it is probably deep since the fault plane is so nearly vertical.

The plane of the fault on the southeast side of the greenstone mass does not appear to be nearly so highly inclined, as the contact has shifted down the dip much more than it has along the other fault. The dip of the Iron formation here is about 85° southeast.

The shattered condition of the rocks on these claims has permitted the circulation of water containing sulphates or sulphides in solution, and iron pyrite has been freely deposited as a secondary constituent in part of the Iron formation and much of the greenstone. This pyrite is weathered on the surface to iron oxide giving to

the rocks a reddish stain. The formation on these claims is very hard, being composed largely of jasper, but it contains enough magnetite to make the compass useless in the vicinity of the range.

As mentioned previously, diamond drilling was done on these claims last summer. A hole was sunk in the jasper northwest of the fault plane, it being considered that a concentration of iron oxide might have occurred along the fault. Through the kindness of Mr. R. H. Flaherty, under whose direction the drilling was done, it was learned that the hole, which reached a depth of 351 feet directed at an angle of 60° toward the face of the hill and nearly at right angles to the fault plane, was entirely in jasper. There seemed to be little difference in the rock as the hole deepened.

The Miller Claims

About three miles east of the Winter Camp claims and lying along the south side of Johnson creek there are three 40-acre claims. The Iron formation is exposed on only two of them, but the appearance of the range on either side of a swamp covering the centre claim and local attraction in this swamp indicates a continuation of the range beneath it. The outcrop begins at the creek a little west of the western claim, where it is indicated by narrow bands of jasper or magnetite and silica lying in wider bands of slaty schist. The schist is so prominent that the range is of no importance until the western claim is reached, where a mass of jasper and banded silica and magnetite is exposed in trenches. The range crosses the claim, disappears beneath swamp and reappears on the eastern claim of the group, where a mass of bright red jasper has been exposed by stripping. This outcrop is 275 paces long and at widest exposure 30 paces in width. The strike is 100°, and the dip about 55° northward. The formation dips under swamp along the north side, mixes with schist on the south and disappears in drift and swamp at either end. One striking feature about the range here is the fine polish left by the glacier on the folded jasper, which is so hard that it has retained this polish almost perfectly.

At a distance of half a mile in a direction of 100° the range again outcrops on the side of a hill rising 40 feet above the swamp which extends away to the north. The outcrop here is 280 paces in length and in the widest part is 100 paces in width. The formation is composed of jasper and banded magnetite and silica in a slaty schist. A thin section of this schist showed under the microscope an indefinite fairly fine grained ground-mass in which there were numerous crystals of magnetite and some of pyrite. Most of the pyrite crystals were partly oxidized to magnetite, and showed the origin of some of this mineral. There were also crystals and fragments of tourmaline, generally lying along definite lines, having no doubt assumed this arrangement under shearing stresses. The minor folding in the range is complex, and some narrow bands of jasper have been so doubled up and then nipped off, that in a few instances pebble-like masses have been left in the slaty schist. This is an exceptional way for such fragments to be formed, but every stage of the process may be found somewhere in the range.

The formation dips northward under a large swamp at an angle of 80°, and the outcrop drops down into swamp to east and west. On the north side it is underlain by a felsite with apparent brecciated structure. Following out the general direction of strike of the range, it would cross a large mass of quartz-porphyry, or rhyolite, lying on the other side of a valley, and therefore the outcrop described represents the most eastern extension of the range.

On the western claim of the Miller group, Mr. Flaherty had a hole drilled to a depth of 139 feet at an angle of 52° south. There were four feet of mantle rock and the remainder of the hole was in jasper and greenstone, there being altogether 31 feet of the former. This shows that the formation at this point is comparatively shallow and that the felsite dips under it. It also strengthens the writer's opinions, formed previously, that the formation would not prove to be very deep over most of the syncline.

Other Outcrops on this Range

Lying in the large swamp northeast of the Miller claims is a small outcrop of Iron formation composed of schist and jasper which is of importance only in showing the extent of the range in this direction. There are a number of outcrops extending from the 12th portage on the Red Paint along the lakes eastward toward the Height of Land. These are not important, but represent the continuation of the range in this direction. A number of claims have been staked on these outcrops, but no development work has been done.

South of the Miller claims there are some scattered outcrops and stringers of the Iron formation. The strike of the rocks there is about 100°. The jasper lies in green schist which is connected with the schist of the main range to the northwest, and this offshoot appears to be due to the large masses of igneous rocks which have caused an irregularity in the folding of the sediments by compelling them to assume the form of a syncline between prominences of massive rock.

Although a number of claims have been staked on these outcrops and some pits dug through the drift for exploration purposes, there does not seem to be any important development of the Iron formation here.

The Bain Claims

During the spring of 1907 a prospector named C. Bain located an extensive outcrop of the Iron formation about three miles south of the Height of Land portage. The writer visited this range late in the season and expected to return to complete the examination and mapping of it, but was compelled to leave the field before this was accomplished. As the exploration of this range as well as some of the other outcrops in the region will probably be continued during the coming field season, only a brief account of it will be presented and no analysis of ore from it will be given at this time.

Six claims had been staked and a considerable amount of stripping done, so that the range was well exposed. In one trench the range was stripped transversely for 80 feet and it was nearly free from schist. Another trench 130 feet long shows the formation in the trench to be composed largely of jasper. Magnetite and specular hematite are common constituents of the formation, and in some cases the percentages of these are high enough to make low grade ore. The amount of hematite is greater comparatively towards the eastern than at the western end.

The range fingers out into schist at the west end and runs under swamp to the eastward, but judging from the effects of magnetic attraction it continues some distance east while obscured from view beneath drift and swamp. The association of the Iron formation with the country rock is much the same as on the range farther north. An altered white porphyry extends along the southern side of the range and in some places is closely folded into it. In another place the formation is cut by an irregular mass of diabase. The strike of the rock is about 95°, and it runs nearly parallel with the range to the north. The dip is generally about 70° northward, but it varies to 90°.

Trombley's Claims

There is a group of claims locally known as Trombley's claims lying along St. Marie lake about eight miles west of the Height of Land portage. Some interest was attached to these on account of the reports that pyrrhotite was the iron-bearing mineral of the formation there. A short visit was paid to the district, and a lean iron range was found containing pyrrhotite and pyrite as secondary constituents, the Iron formation having been greatly brecciated by the intrusion of diabase so that solutions could permeate the rocks and form deposits of the sulphides.

The range has a maximum width of 500 feet with a strike of about 50°, and dip which varies from 45° to 90°, as the rocks have been greatly displaced by the igneous intrusions. The range is apparently of no commercial value.

Iron range, C Bain's claims, Height of Land, Red Paint river.

Typical prospector's camp, C. Bain's claims, Height of Land.

A specimen of the Iron formation was examined in thin section, when it showed a banded rock composed of crystals of quartz, many of them six-sided and with small grains of magnetite along certain lines. The quartz crystals along the bands colored darker by magnetite were generally of smaller dimensions than those between these bands, which may be due either to the sands which were deposited at the time the magnetite was formed being finer grained than those deposited at other times, or to the detrimental effects of the magnetite on secondary crystallization. Both the macroscopic and microscopic appearance of the rock is that of a recrystallized sandstone with dark bands of magnetite running through it.

Iron Formation on the Red Portage

A number of years ago the Algoma Commercial Company surveyed a number of claims around the ninth portage of the Red Paint river. This portage is commonly known as the "Red" portage, because the surface of the ground over which the trail passes is stained red by hematite. There is no iron of commercial importance on the claims, but there is a band of the Iron formation lying along the lake just below the portage and extending across the portage, gradually mixing with and being lost in the country rock. The formation consists of a banded sugary quartz rock, which might be a recrystallized sandstone, containing small streaks of magnetite. As the contact between the Iron formation and the Laurentian granite lies along the lake, the former has been greatly affected by the intrusion of the latter, and as in every other case observed, where a large mass of igneous rock intrudes an Iron range, there is a dissemination of pyrite through the range. This deposit of pyrite may be due either to percolating waters which accompanied the intrusion, or to disseminating gases; very probably the former. As to whether the iron of the sulphide accompanied the intrusive rock, or whether sulphur vapors or solutions which were associated with it acted upon some of the iron oxide in the range, converting it into sulphide, is not clear. The sulphide here has weathered on the surface to hematite and yellow ochre. Along the south side of the outcrop of the Iron formation there are garnetiferous schists which have been developed by the contact action of the granite on the Keewatin rocks.

Lower Huronian (?) Conglomerate and Arkose

The conglomerate is not nearly so widely distributed in the Onaman Iron range region as it is in the Poplar Lodge and Wendigokan regions. The largest outcrop found lies along Johnson creek a short distance above the Miller group of claims. There a ridge 450 paces long and 120 wide stands about 25 feet above the stream, and disappears on all sides beneath drift or swamp, so that no contact with any rock is visible. Another very small outcrop appears above the drift near the Iron range on the Miller claims, and is no doubt a continuation of the ridge already described. About two miles farther east here is a small outcrop of rock which might be mistaken for conglomerate, but it is very probably a brecciated quartz-porphyry.

The pebbles of the conglomerate so far as observed are all of acid porphyry.

A thin section of this conglomerate was examined and numerous round and angular fragments of quartz were found. Some of these had been crushed and largely recrystallized. Some masses of iron pyrite were scattered through the rock as if deposited from solution around crystals of other minerals which acted as nuclei. There were fragments of tourmaline crystals and these were without exception surrounded by iron pyrite, though there is no particular reason known why they should have been. The tourmaline was probably derived from the quartz-porphyry which supplied the pebbles for the conglomerate, and which generally contains a good deal of this material.

There are a few outcrops of arkose in the region which are doubtless associated with the conglomerate, but they are so scattered and small that they were not

definitely worked out. One of these occurs along the north side of the Iron range on the Height of Land, and a thin section of this rock shows it to be composed of fragments of feldspar and quartz, among which there is a good deal of iron carbonate mostly arranged around their borders, numerous crystals of pyrite, a little chlorite with some magnetite—probably derived from the chlorite and associated with it—and small amounts of hornblende and biotite. Another specimen was taken about a mile and a half north of the Height of Land. This contains some fragments of quartz slightly rounded, and around each fragment of quartz and feldspar there is a coating of iron oxide. This arkose has the composition of one which might have been derived from the disintegration of a quartz diorite. Possibly some of these arkoses represent formations of small extent formed on the land by small streams washing materials from the high land and depositing them on the flats.

Greenstones and Green Schists

The typical meta-igneous greenstones of the Keewatin are well developed in this region. Large areas are covered by massive greenstone which in many places shows, in its brecciated and pillow structures, abundant evidences of its extrusive nature. These rocks have retained their massive condition to a much greater extent in this region than in some of the other Iron range regions, and on this account there does not seem to be the usual great series of schists developed from them. They have intermingled with porphyries to a large extent, the greenstones representing the basic lavas and the porphyries the acid lava flows. These rocks are too much altered to be suitable for study in thin section, though in some cases they retain their structures sufficiently well to indicate that they are largely composed of diabase usually carrying a little quartz. One section showed considerable leucoxene which is an alteration product of ilmenite, and forms brown aggregates, which are highly refracting and if transparent, highly doubly refracting. In incident light the mineral is white.

The green schists are more highly developed west of the immediate neighborhood of the iron ranges than within it. There is a large area of them extending westward from the Height of Land and down the Red Paint to lake Oboshegegon. These schists have been developed from rocks of various types, and no attempt was made to separate them from the greenstones in the mapping of the region, nor to work out their origin. They represent metamorphosed greenstones, porphyries, tuffs, and probably arkoses and graywackés.

The Acid Porphyries and Tuffs

In no other Iron range region with which the writer is familiar is there such a development of porphyritic rocks of the acid type. Although there are in this region plagioclase-porphyries, orthoclase-porphyries and quartz-porphyries, they are almost all old lavas and can be regarded as felsites, or ancient rhyolites. They are all more or less metamorphosed and often without definite structure in macroscopic specimens.

They are so intimately connected with the two main Iron ranges of the region that a geologist in the field is often uncertain whether they have been folded into the Iron formation, intruded into it, or interbedded with it as extrusive masses. So close has the folding been that field relations are obliterated. One large mass of plagioclase-porphyry about a mile north of the Height of Land portage contains macroscopic phenocrysts of plagioclase, with rhombic outlines similar to those in the rhomben-porphyry of Norway. One striking feature of the felsites is the brecciation of the rocks. This structure probably originated when the cooling lava rolled and cracked as it flowed along, and is best seen at the twelfth portage on the Red Paint, where there are fragments as much as eight inches long. It is more or less common in most of these rocks, in many cases being emphasized by weathering action. Some of

the finer grained types of quartz-porphyry have the appearance of horn and in some respects resemble chert, so that a mass of it is locally known as "Chert Mountain." Along the Bain claims the surface of the felsite is in places nearly white with a coating which will readily rub off. This is probably an efflorescence of calcium or magnesium carbonate.

As these rocks make good thin section, a number of them were examined. One section from a specimen of the felsite along the south side of the Bain claims shows phenocrysts of microcline; some of these have been crushed, and recrystallization has occurred along the edges of the crystals. The phenocrysts lie in a fine grained groundmass of quartz and orthoclase, much of which is weathered to muscovite. The groundmass has been largely recrystallized, and it is quite probable that the microcline is recrystallized orthoclase, as microcline is not found as a pyrogenetic mineral in lava flows. There is a large amount of tourmaline which exists as euhedral prismatic crystals, generally long and rather slender, with bluish color and very strong pleochroism. This mineral is probably pyrogenetic, as the crystals have been dragged and broken during the shearing processes which have affected the rock. A few crystals of apatite are present.

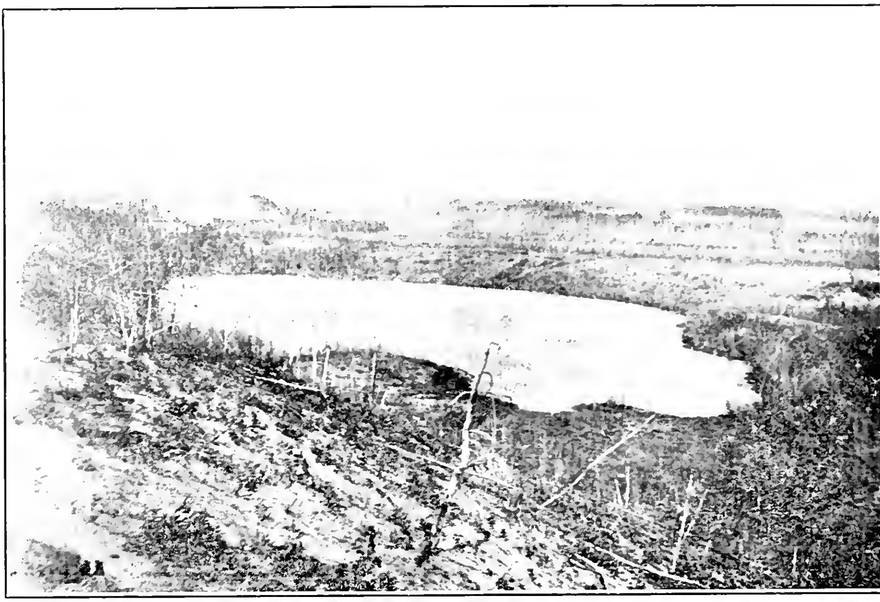
Another specimen was taken from the large mass of felsite east of the Miller claims. This rock contains numerous rounded phenocrysts of quartz as well as of weathered potash feldspar. The rounding of the quartz crystals is supposed to be due to the corroding action of the ground-mass and is characteristic of the phenocrysts of recent quartz-porphyries. There is a little tourmaline in this rock as well as some magnetite, pyrite and calcite. The pyrite is largely coated with iron oxide.

About one mile south of the kettle lakes lying along Johnson creek a couple of miles west of the Miller claims, an interesting dike about two feet wide was found. The rock is of a light gray color on the weathered, dark gray on the fresh surface, and spotted white with feldspar phenocrysts lying in a fine grained groundmass. Some plates of light and dark mica are also to be seen in the hand specimen. A microscopical examination shows the rock to be an orthoclase or syenite-porphyry, with distinct phenocrysts of orthoclase twinned according to the Carlsbad law. One crystal of plagioclase has a composition between that of andesine and labradorite, and another shows zonal structure in a combination probably of albite and anorthite. The biotite has mostly changed to chlorite. Several plates of phlogopite contain small alteration crystals of iron oxide and fine rutile needles, the latter with a radiating arrangement. A good deal of recrystallization has occurred and some flow structure due to crushing and shearing is seen. Some small crystals of apatite are scattered through the groundmass, which is composed largely of feldspar and secondary mica.

The tuffs were not recognized in many places in the region. On the Winter Camp group there is an outcrop of tuff which lies beneath the Iron formation. It contains a good deal of iron carbonate weathering brown on the surface to a depth of one-quarter of an inch, and it has a sort of banded structure which is doubtless due to bedding. It has a composition much like that of an arkose, but differs from it in having much more carbonate than usually occurs in the arkose of the region and in the absence of liquid inclusions in the quartz. It has the composition of a pyroclastic rock corresponding to a quartz-porphyry. In this region are doubtless considerable masses of tuffs now so completely metamorphosed as to be indistinguishable from the other green schists, but taking the region as a whole there is a marked scarcity of this type of rock when compared with the Michipicoten or Sturgeon river regions.

The Laurentian

Three bands of Laurentian granite and gneiss occur along the Red Paint river. Around the mouth of the stream there is a large mass of gneiss, where the processes by which banded gneiss is derived by the inclusion of masses of Keewatin greenstone in the granite and the subsequent rolling out of the same, are remarkably well



Kettle lakes, Johnson creek

Kettle lakes, Johnson creek.

illustrated. On the third portage where the second band of granite comes in contact with the greenstone there is a little diorite, which seems to grade into the granite and to represent a contact phase of that rock. This band is found on all portages as far up as the eighth, and the contact between it and the greenstone occurs just below the ninth or "Red' portage. Granite appears again just above this portage, and extends to near Lake Oboshegegon.

The only Laurentian found in the region mapped is a small mass of hornblende granite about 300 paces in diameter lying about two miles southeast of the small twin lakes on Johnson creek. This probably represents an offshoot of the main granite body which is said to be exposed about six miles south of the Height of Land portage.

Basic Eruptives

There are numerous outcrops of diabase and gabbro scattered over the iron range district. The age of these is uncertain, because there are no younger and few older formations associated with them, but on account of their resemblences to the other Keweenawan rocks so common in the Nipigon region, they probably represent isolated bodies in some way related to the larger basic eruptive masses around the lake, and the writer has classified them in the same system.

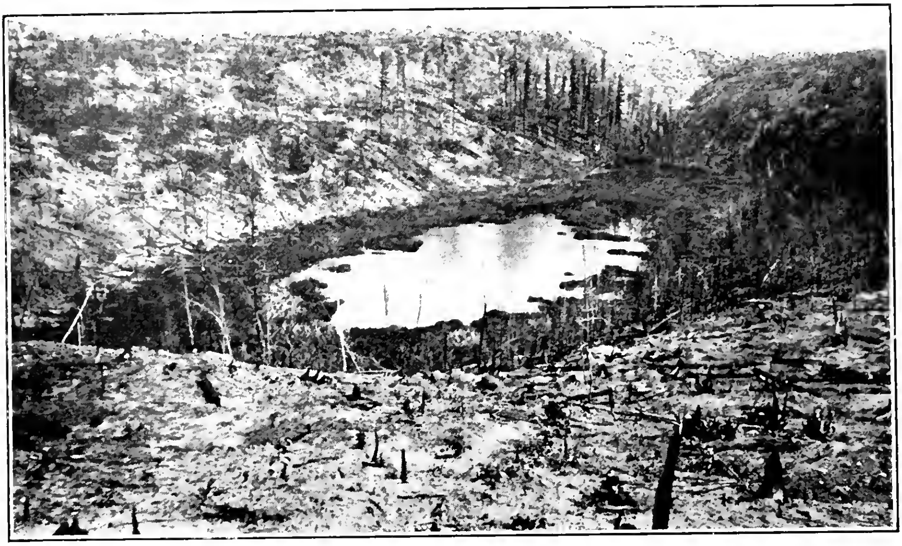
The largest outcrop observed lies on the trail between the Height of Land portage and the Bain claims. There a batholith of gabbro about 270 paces in extent has broken through the greenstone and carried off fragments of it. Along the south shore of Nixon lake a portion of a diabase dike about 30 paces wide was seen, but it could not be traced any distance on account of the drift which overlies it. The general direction of the dike is 110°, and it is probably exposed in other places farther east. Some masses of diabase and gabbro have broken through the iron ranges on the Maple Leaf and Bain claims.

About a mile and a half south of the Height of Land portage a specimen of quartz-gabbro was taken. It was blotched with yellowish green minerals resembling serpentine, but which under the microscope were found to be labradorite feldspars partially altered to chlorite. The quartz crystals contained little inclusions of apatite. The ferro-magnesium minerals were augite, partly altered to chlorite, and hornblende, and much iron pyrite some of which had been oxidized to magnetite.

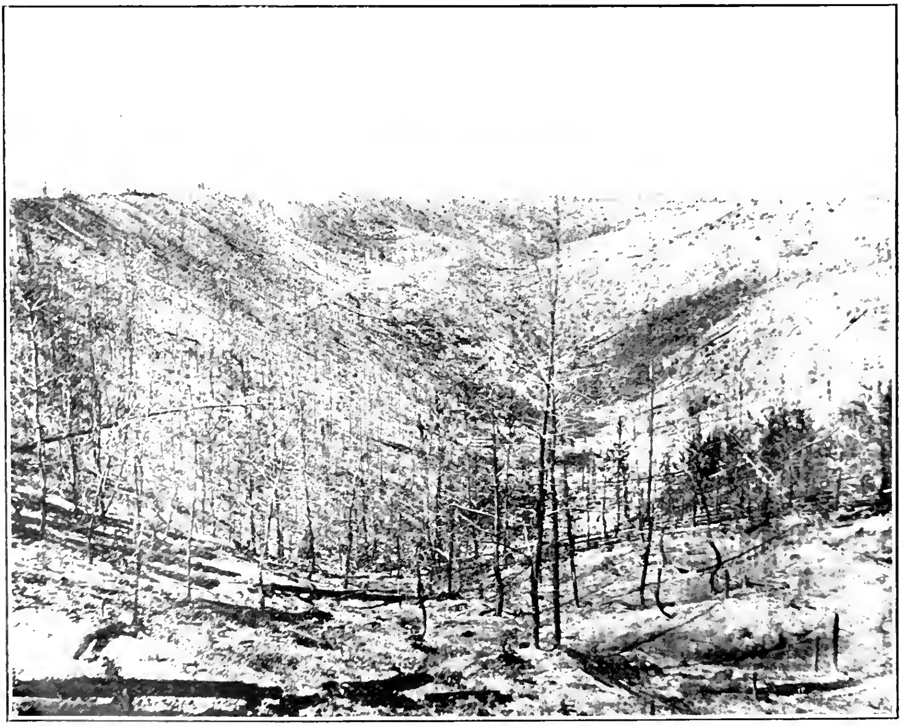
Gabbro is the most common of these basic rocks, and it generally occurs in small bosses or batholiths.

Pleistocene Geology

The first portage on the Red Paint river crosses a well developed sand and clay plain having an elevation of about 75 feet above lake Nipigon. Between the first and second portages a continuation of this plain is seen rising about 30 feet above the stream, but as one proceeds up the river the sand and clay banks become less conspicuous. Around the Height of Land there are many flat areas covered with stratified clay and silt, and though some of these may have been covered by local glacial lakes, most of them represent portions of the bottom of the large lake which covered a great part of the Nipigon region in Pleistocene time. Some stratified gravel and coarse sand are also found around cache 12 A, and the pebbles of the gravel are often coated with lime carbonate. Above these stratified deposits there rises a series of irregular morainic hills with no signs of terraces along their faces nor evidence that they have ever been covered by water, and the writer concluded that the ice had for a time formed the north shore of the lake, but that the outlet had been changed so as to lower the surface of the lake, and consequently at the time these hills were formed its border did not reach as far northeast as the Height of Land. Unless our calculations are in error there are sand plains on Battle Island lake, an expansion of the Sturgeon river, with an altitude of at least 1,090 feet, which is greater than that of some of the drift hills in this region that do not appear to have been covered by the lake.



Kettle, near Height of Land.



Dry Kettle, Johnson creek.

On the north side of Johnson creek about five miles east of the Height of Land there is a fine series of drift hills which have been swept perfectly bare by bush fires, and now form conspicuous features. They rise about 90 feet above the stream and among them are numerous depressions some of which contain kettle lakes, there being as many as six of these visible from one of the hilltops. North of these hills there is a large area covered by ground moraine with extensive swamps which are characteristic of ground moraine regions.

This series of hills extends almost directly westward for at least ten miles, and in places the hills reach an elevation of 1,200 feet above sea level. They also extend to the east, and on the southeast side of Johnson creek about three miles from the Miller claims a series of hummocky ridges begins and extends as far east as the eye can reach. One low esker was seen extending with serpentine outline nearly north from these hills.

Another smaller group of hills, among which there are four kettle lakes, is found on the south side of Johnson creek, between the Miller claims and the Height of Land. These hills probably represent the deposits of moraine made at the edge of a lobe which was for a wihle extended about a mile farther south than the main ice front.

This great series of terminal moraive hills represents the deposits made where the edge of the glacier remained nearly stationary for a long period before it finally retreated rather rapidly northward.

The striations made on the rocks by the ice have a direction of 60° where they were noted. The directions of these striations may be made use of by the prospector as indicating the general direction from which the boulders of Iron formation have come, and thus assist him in locating an Iron range. Although some of these boulders may travel great distances, the greater number of them are of comparatively local origin. The finest examples of glacial polishing which the writer has ever seen were found on the jasper of the Miller claims.

THE IRON AND STEEL INDUSTRY OF ONTARIO

BY GEORGE CLEGHORN MACKENZIE

I.—Historical and Statistical Review

NOTE.—The statutory ton in Canada is 2,000 lb., but the standard in almost universal use in buying and selling iron ore and pig iron in Great Britain, the United States and Canada, is the English or "long" ton of 2,240 lb., and throughout this article the latter is employed, unless it is expressly stated that the "short" or "net" ton of 2,000 lb. is intended.

The early history of ironmaking in Ontario is, with one exception, a chronicle of disaster and failure in the attempt to produce iron from our native ores. Many thousands of dollars were spent in opening up mines, building furnaces and manufacturing charcoal, and although some of the pioneers in the industry were fairly successful at the start, and apparently could make pig iron at a profit, the business languished and failed to take root.

It must be remembered, however, that the iron-masters had then what would be considered now-a-days almost insurmountable difficulties to contend with; the methods of transportation were crude and costly; the old fashioned furnaces consumed much fuel to make a ton of iron; and, most important of all, there were very few men in the country who thoroughly understood the operation of the blast furnace, much less the proper methods of smelting the hard, dense magnetic ores of the back townships.

The Catalan forge did not seem to play any part in Ontario, or Upper Canada as it was then called, in the making of iron. This is somewhat remarkable, as many of these primitive furnaces were being worked at that time in the United States, and it is natural to suppose that early Canadian ironmasters would have followed suit. The Catalan forge, it should be explained, yielded impure wrought iron, and under the most favorable circumstances could not produce more than 300 pounds of metal daily.

Early Efforts at Ironmaking

A very complete description of the first attempts made in Upper Canada to manufacture iron will be found in the Report of the Royal Commission on The Mineral Resources of Ontario, 1890, page 319. The following notes have been taken largely from this report.

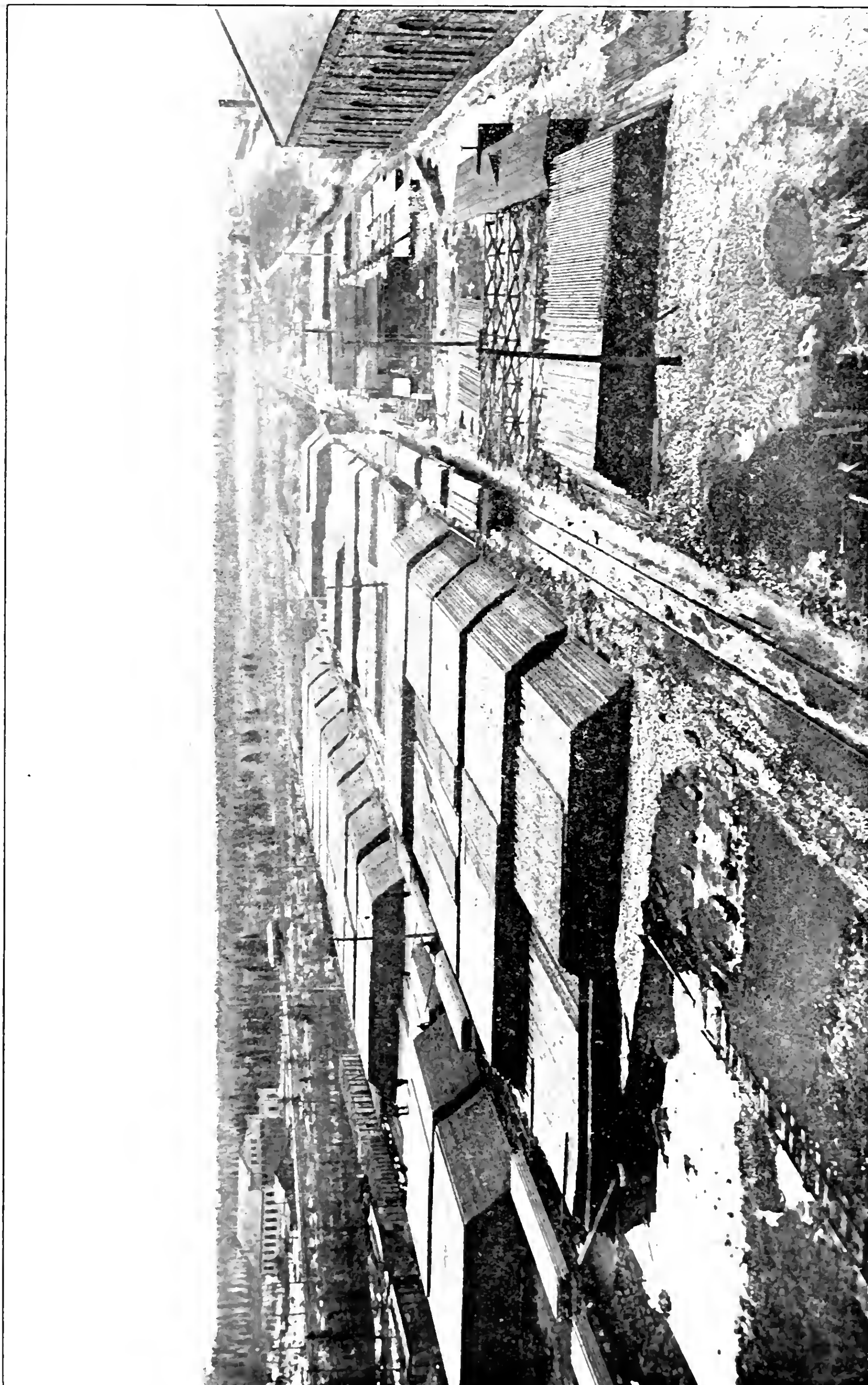
Furnace Falls

About the year 1800, four men, Ephraim Jones, Daniel Sherwood, Samuel Barlow and Wallace Sutherland, formed a company for the purpose of making pig iron They built a furnace at what was then called Furnace Falls, on the Gananoque river, in the county of Leeds. The ore used was of poor quality, and had to be hauled a considerable distance. Attempts were made to cast pots and kettles for the settlers, but after two years of unsuccessful work the furnace was abandoned as a failure.

The Normandale Furnace

John Mason, an Englishman, was the next man to make the attempt. He built a furnace on the shore of Lake Erie at the mouth of Potter's creek in the township of Charlotteville. The creek was large enough to furnish power for the old fashioned wooden blowing engine, and the lake was convenient for shipping the product. That Mr. Mason had plenty of troubles will readily be seen from the following extract of a letter he wrote to Robert Gourlay in 1817:

I want five or six pieces of cast iron each 30 cwt. These will come to an enormous expense. I intended to ask Government to give or lend me six disabled cannon for this. I asked Government to pay the passage of five or six families from England to work in the furnace. This could not be granted, and therefore I would not ask for the cannon. Another thing against me is, that there is not a man in the country that I know of capable of working in the furnace. But the greatest difficulty I have to overcome is iron-men, as we call them, are the very worst sort of men to manage, colliers



Rail storage yard, the Algoma Steel Company, Sault Ste. Marie, Ont., April 1st, 1907, showing 73,000 tons rails stored for opening of navigation.

not excepted. Not one of a hundred of them but will take every advantage of his master in his power. If I have just the number of hands for the work, every one of them will know that I cannot do without every one of them, therefore, every one will be my master.

Mr. Mason's furnace had hardly been blown in before the inner lining gave way, and the whole enterprise was given up in despair. Mason soon afterwards sickened and died.

The works remained idle until 1820, when they were bought by Joseph Van Norman, who in the following March formed a company with Messrs. Hiram Capron and George Tilson. These men expended $8,000 on improvements and repairs, and in 1822 the furnace was again in blast under the management of Joseph Van Norman, who gave the name of Normandale to the locality. The bog ore supply was found within a radius of twelve miles or so, and drawn to the furnace in wagons. The yield of iron from the ore was about 33 per cent., nine tons of ore being consumed daily to make three tons of pig iron. Charcoal was the fuel used and the consumption per ton of iron produced was very high. The furnace was in blast eight or nine months of each year, producing 750 tons of iron and using about 4,000 cords of wood. Allowing 40 bushels of charcoal to the cord of wood, it will be seen that 213 bushels were consumed per ton of pig iron.

There being no sale for pig iron, the whole of the output was made into various kinds of castings, stoves, kettles, etc., and shipped to ports along the lake shore from Fort Erie to Amherstburg. A considerable amount was hauled into the interior for the retail market. There was little money in the country in those days, and what the farmers had to sell was brought to the furnace and exchanged for wares or due bills of the company. Due bills for iron were used as a circulating medium over a large section of the Province, and at one time the books of the company showed an amount of $30,000 outstanding.

After five or six years Joseph Van Norman bought out the interests of Messrs. Capron and Tilson and took in his brother Benjamin, who retired a few years after, and from that time until 1847, when the furnace was shut down owing to scarcity of fuel and ore, the business was conducted in the name of J. Van Norman & Son. The enterprise seems to have been ably managed from first to last, and Mr. Van Norman made a fortune which he lost elsewhere.

It is extremely interesting to note that means were employed at the Normandale works for utilizing the waste gases of the furnace, in calcining the ore and heating the blast. The late G. R. Van Norman, Q.C., of Brantford, son of Joseph Van Norman, is quoted as follows:

> It is not claimed that Mr. Van Norman was the original inventor of the hot-air blast which was patented by J. B. Neilson of Glasgow in 1828, but that he used and applied it without a knowledge of Neilson's invention. He invented an oven for the double purpose of heating the blast and roasting the ore. By constructing a set of brick ovens or chambers at the level of the charging door and connecting them with the shaft by pipes, Mr. Van Norman was enabled to roast the ore by utilizing the waste gas and heat of the furnace, the hot air blast of the furnace being fed at the same time through pipes connected with the roasting chamber.

Attempts at Marmora

In 1820 a blast furnace was built by a Mr. Hayes on the Crow river, township of Marmora, to treat the magnetic ores of Blairton on Crow lake. Little is known of this enterprise except that Mr. Hayes lost heavily, and the property passed into the hands of the Hon. Peter McGill of Montreal. In 1828 the Legislature was asked by Mr. McGill for a loan of £10,000 for aid in carrying on the works, and in 1831, upon the petition of Messrs. Hetherington, McGill and Manahan, an Act was passed to incorporate the Marmora Iron Foundry. Nothing came of the efforts to interest the Government in the company's affairs, and the business was carried on at a heavy loss.

Mr. Van Norman, after shutting down the Normandale furnace, purchased the Marmora works for $21,000, and in the fall of 1847 moved to Marmora, where, after spending much money on improvements and preparing a stock of ore and charcoal, he started the furnace in the summer of 1848.

This second venture of Mr. Van Norman proved a failure. The ore, being a hard magnetite, was not so easily reduced in the furnace as the soft bog ores of Norfolk county with which he was familiar, and consequently the amount of charcoal consumed per ton of iron made was beyond the profitable limit—"a sad disappointment." The iron, too, after it was made, had to be transported a distance of thirty-two miles to Belleville over a very rough road. A cheaper route was found later by a nine-mile road to Healey's falls on the Trent river, and thence by steamer to Rice lake, where the iron was transferred to wagons and carted twelve miles to the docks at Cobourg The iron found a ready sale at $30 to $35 per ton until the St. Lawrence canals were opened and admitted foreign pig iron, which could be laid down in Belleville and Cobourg for $16 per ton. This circumstance was the death blow to the industry, and Mr. Van Norman was compelled to close his works at a heavy loss.

In 1856 an English company started operations in Marmora, and it is said sunk £75,000, which proved a total loss, the management not understanding the proper treatment of the ore. A few years later the furnace was again in blast under the superintendence of a Mr. Bently. A report of this venture is given in the Geological Survey report for 1866, and it is stated that the furnace worked well, the blast was heated, and the output averaged 5 tons daily from ore that yielded 56 per cent. of

Fig 7.—Staffordshire blast furnace, 1854.

Type of blast furnace common during the middle of last century (now obsolete).

iron, the consumption of charcoal being at the rate of 160 bushels per ton of iron made. However, financial difficulties put an end to the operations, and after a short campaign of forty days the furnace was blown out because funds were not available to pay the workmen.

Smelting with Wood at Madoc

In the village of Madoc in Hastings county another charcoal furnace was built in 1836 by Uriah Seymour of New York State. Considerable iron was made and the furnace was in blast for some time with varying success, until finally the supply of charcoal gave out and Mr. Seymour was forced to suspend operations. It is interesting to note that when charcoal became scarce cordwood was used as fuel, the wood being cut into two foot lengths. About one and a half cords were used per ton of ore

smelted. The cordwood answered very well as fuel as long as the output was kept at about one ton daily, but when atempts were made to drive faster, the wood descended too quickly and was insufficiently charred.

Van Norman's Experiment at Houghton

After Mr. Van Norman's failure at Marmora he returned to his old home at Normandale. The Great Western railway being under construction at that time, a demand was created for car wheel iron, and it was thought that the charcoal iron formerly made by Mr. Van Norman out of the bog ores of Norfolk county would meet the requisite specifications, especially those covering the chilling qualities. Accordingly, a blast furnace was erected in the township of Houghton in the western part of Norfolk, and was blown in during the year 1854. The first shipment of 400 tons of iron was made to Hamilton in 1855, but unfortunately the iron was found wanting in that particular chilling quality which it was supposed to possess, and instead of Mr. Van Norman getting his contract price of $45 per ton, he had to sell the iron for $22. This last venture of Mr. Van Norman cost him and his sons in the neighborhood of $32,000, and closed his career as Ontario's most successful pioneer iron master.

The next venture is hardly worth mentioning, as the works were never completed, and never produced any iron. The site chosen was on the Burnt river, in Haliburton county. An American firm, Messrs. Parry and Mills started in 1882 to build a blast furnace, charcoal kilns, saw mills, etc., but after expending about $60,000 they ran out of funds, and although every effort was made to borrow $10,000, no financial assistance could be secured, and the uncompleted works had to be abandoned a total loss.

Canadian Government Offers Aid

From this date until 1896 the production of pig iron in Ontario amounted to practically nothing. In 1883 the Dominion Government offered a bounty of $1.50 for every ton of pig iron produced in Canada from Canadian ores. This rate continued until 1886, when it fell to $1.00 a ton for the next three years. No stimulus was given to the industry by this bounty, and it was not until after the Hamilton Blast Furnace Company started operations in 1896 that the Dominion Government offered a second bounty system, Chapter 6 of 60-61 Victoria (1897), providing as follows:

$3.00 per ton on pig iron manufactured, on the proportion from Canadian ore.

$2.00 per ton on pig iron manufactured, on the proportion from foreign ore.

$3.00 per ton on steel ingots manufactured from ingredients of which not less than 50 per cent. of the weight thereof consists of pig iron made in Canada.

$3.00 per ton on puddled bars made from pig iron manufactured in Canada.

The period for payment of the bounty extended to April 1902, but Chapter 8 of 62-63 Victoria extended the bounty period to June 30th, 1907, and enacted a sliding scale of payments as follows:

Up to April 23, 1902, the rates fixed by the Act of 1897,

From 23 April, 1902,	to June 30, 1903,	90	per cent.	of the 1897	rate,
" 1 July, 1903,	" June 30, 1904,	75	"	"	"
" 1 July, 1904,	" June 30, 1905,	55	"	"	"
" 1 July, 1905,	" June 30, 1906,	35	"	"	"
" 1 July, 1906,	" June 30, 1907,	20	"	"	"

and it was further provided that no bounty should be paid on steel ingots made from puddled bars.

In April, 1907, the Dominion Government passed a third bounty Act, to remain in force until 1910. This Act makes special provision for the manufacture of iron and steel by electricity. The bounty rates are as follows:

1.—(*a*) In respect of pig iron manufactured from ore, on the proportion from Canadian ore, produced during the calendar year:

1907	$2.10 per ton.
1908	2.10 "
1909	1.70 "
1910	.90 "

(*b*) In respect of pig iron manufactured from ore on the proportion from foreign ore, produced during the calendar year:

1907	$1.10 per ton.
1908	1.10 "
1909	.70 "
1910	.40 "

(*c*) On puddled iron bars manufactured from pig iron made in Canada,

1907	$1.65 per ton.
1908	1.65 "
1909	1.05 "
1910	.60 "

(*d*) In respect of rolled round wire rods not over 3-8 of an inch in diameter manufactured in Canada from steel produced in Canada from ingredients of which not less than 50 per cent. of the weight thereof consists of pig iron made in Canada, when sold to wire manufacturers for use, or when used in making wire in their own factories in Canada, on such wire rods made after 31st of December, 1906, $6.00 per ton.

(*e*) In respect of steel manufactured from ingredients of which not less than 50 per cent. of the weight thereof consists of pig iron made in Canada during the calendar year:

1907	$1.65 per ton.
1908	1.65 "
1909	1.05 "
1910	.60 "

2. The Government in Council may authorize the payment out of the consolidated Revenue Fund of the following bounties on the undermentioned articles when manufactured in Canada for consumption therein, namely:

(*a*) On pig iron manufactured from Canadian ore by the process of electric smelting during the calendar year:

1909	$2.10 per ton.
1910	2.10 "
1911	1.70 "
1912	.90 "

(*b*) On steel manufactured by the electric process direct from Canadian ore, and on steel manufactured by electric process from pig iron smelted in Canada by electricity from Canadian ore during the calendar year:

1909	$1.65 per ton.
1910	1.65 "
1911	1.05 "
1912	.60 "

(*c*) Bounty as on pig iron under this section may be paid upon the molten iron from the ore which in the electric furnace enters into the manufacture of steel by the direct process, the weight of such iron to be ascertained from the weight of the steel so manufactured.

Also no bounty shall be paid on steel ingots from which steel blooms and billets for exportation from Canada are manufactured.

The following statement shows the quantities of Canadian and foreign ores used by smelting companies in Canada in the manufacture of pig iron during the nine

months ending 31st December, 1907, the quantities of pig iron made from each kind of ore and the amount of bounty paid thereon:

Company	Tons of Canadian ore used.	Tons of Foreign ore used.	Tons of Pig Iron made from Canadian ore.	Bounty paid on Canadian pig.	Tons of Pig Iron made from Foreign ore.	Bounty paid on Foreign pig.
				$		$
Dom. Iron & Steel Co., Ltd.	64.96	479,242.04	33.60	70.56	228,994.77	251,894.25
Hamilton Steel and Iron Co., Ltd.	45,753.80	69,222.66	26,436 24	55,516.09	35,613 71	39,175 07
N. S. Steel & Coal Co., Ltd	1,269.00	83,885.90	458.00	961.80	42,995.11	47,294 62
Can. Iron Furnace Co. (Radnor)	10,180.95	1,891.32	4,603 21	9,666.74	1,051.85	1,157.04
do do (Midland)	3,689.73	28,770.94	1,852.05	3,889.33	15,374.72	16,912.18
John McDougall & Company	4,993.19	....	1,924.87	4,042.27	....	....
Londonderry Iron & Min. Co., Ltd.	54,793.00	....	14,596.39	30,652.42	....	....
Algoma Steel Co., Ltd.	31,203.07	166,633.79	17,336.01	36,405.63	87,210.12	95,931.14
Deseronto Iron Co., Ltd.	1,239.00	6,717.00	626.00	1,314.60	2,884.00	3,172.40
Atikokan Iron Co., Ltd.	14,444.63	....	8,195.47	17,210.46	....	....
Totals	167,631.33	836,363.65	76,061.81	159,729.90	414,124.28	455,536.70

Ontario Government Bonuses Iron Mining

The Province of Ontario also instituted a bounty system, but preferred that it should be paid to the producers or miners of iron ore. In 1894, the Legislature by chapter 16 of 57 Victoria, set aside $125,000 as an iron Mining Fund, out of which there might be paid to producers or miners of iron ore in Ontario smelted in the Province a bounty at the rate of $1.00 per ton of the pig metal product of the ore. The period of this bounty was subsequently extended to January, 1906, but there was a limitation to the effect that not more than $25,000 should be paid out in any one year, and if the quantity of ore mined and smelted in any year exceeded the equivalent of 25,000 tons of pig iron, the bounty should be proportionately reduced. Special provision was also made in the Mines Act for payment of bounty out of the Fund on pig iron made by furnaces using charcoal or peat as fuel, such bounty to be at the rate of $1 per ton on the product of Ontario ores, and 50 cents on the product of ores not mined in Ontario, with the limitation that the following proportions of Ontario ores were to be used:

First two years not less than			20	per cent.
After two years	"	"	40	"
" four "	"	"	60	"
" six "	"	"	80	"
" eight "	"	"	100	"

The amounts paid out of the Iron Mining Fund of Ontario since its establishment have been as follows:

Year.	Pig Iron Made. Tons.	Bounty Paid. $
1896	4,000.00	4,000.00
1897	2,603.95	2,603.95
1898	8,647.19	8,617.19
1899	12,752.07	12,752.07
1900	6,737.80	6,737.80
1901	55,214.00	25,000.00
1902	53,868.22	25,000.00
1903	26,699.28	25,000.00
1904	50,715.17	15,236.19
Sundry expenses	....	22.80
Totals	221 237.68	125,000.00

No provision having been made by the Legislature for the extension of the above bounty, the Iron Mining Fund is a thing of the past.

Reviving the Industry at Hamilton

The Hamilton blast furnace was blown in on December 31st, 1895, and marked the starting point for the manufacture of iron and steel in Ontario on a scale approaching modern requirements. The furnace had a rated capacity of 150 tons of iron daily, the fuel used being coke imported from the United States; hence this furnace was the first to manufacture coke iron in Ontario. The ores used at first came chiefly from the Lake Superior district, although a considerable amount of magnetite was smelted that was mined at Calabogie in Renfrew county, Ontario. When the Helen mine in Micipicoten started operations large quantities of this ore were shipped to Hamilton yearly, and up until the present time it forms a liberal share of the ore mixture at the Hamilton furnaces. The Company had its full share of troubles incidental to the establishment of a new industry, in a locality where furnace labor was hard to secure and the assembling of suitable raw materials difficult. Perseverance won, however, and after amalgamating with the Ontario Rolling Mills in 1899, the new organization, known as the Hamilton Steel and Iron Company, started on a successful career, and is to-day in a flourishing condition.

The system of bounties inaugurated by the Federal and Provincial Governments had the desired effect of stimulating the iron industry of the Province, and the years immediately following witnessed the building of new furnace plants in various parts of the Province. Strenuous efforts were put forward to utilize Ontario ores as far as possible, thus taking advantage of the liberal bounties offered. Iron mining took a new lease of life, and prospecting for iron ores became more general. Old mines were opened up along the Kingston and Pembroke and Central Ontario railways, and for a time ore was shipped in small quantities. Unfortunately the quality of the ore mined was poor. Much cobbing had to be done to get rid of sulphur and other deleterious elements, and as operations were carried on in a small half-hearted fashion, there could be but one result, and that was the abandoning of iron mining in that district. However, an important discovery of brown hematite ore was made in Michipicoten in 1899, which has since developed into the Helen mine, Ontario's largest producer of iron ore up to date. Blast furnace men were not slow to take advantage of the opportunities this new ore offered, and many thousand tons have been smelted in Ontario during the past six or seven years.

Charcoal Iron at Deseronto

The next furnace to get under way was that of the Deseronto Iron Company of Deseronto. This was a small charcoal furnace of about 50 tons capacity, built during 1898 and blown in January 25, 1899. Fuel was supplied by the Standard Chemical Company, whose kilns were but half a mile from the blast furnace. Lake ores were used principally, although some attempt was made to use the magnetite from Belmont in Hastings country. In late years the Standard Chemical Company found it increasingly difficult to secure wood at reasonable prices for manufacturing charcoal, and in October, 1906, the blast furnace had to blow out on account of not being able to obtain enough charcoal. After various repairs had been made, and the furnace bosh enlarged a foot in diameter, another campaign was started on 16th September, 1907, using coke as fuel, and since that date the furnace has worked continually.

Canada Iron Furnace Company at Midland

The Canada Iron Furnace Company, Limited, that had carried on a well established and prosperous business at Radnor Forges in the Province of Quebec, next entered the field in 1899, and erected a 125-ton blast furnace at Midland on the Georgian bay. The locality chosen was a particularly good one, for not only were freight rates on ore and coke about equally balanced, but the market was within easy distance by land and water.

The company's original intention was to manufacture charcoal iron in Midland, but cordwood lands in the vicinity took on so inflated a value that it was decided

to use coke as fuel, and the furnace has continued to use coke ever since. The ores smelted are a combination of Lake Superior and native ores. A large tonnage of Helen ore was used some years ago, but latterly the furnace product has been Bessemer iron, and Lake Superior ores are necessary for this class of pig. Magnetite from the Mineral Iron Range Mining Company at Bessemer, Ontario, is used to some extent and so far has given every satisfaction.

Works at Collingwood

In 1901 the Cramp Steel Company was organized, and intended to erect blast furnaces, open hearth furnaces, and rolling mills at Collingwood, Ontario. The open hearth and rolling mills were completed, but the blast furnaces were not built, and neither the open hearth department or rolling mill has ever seen hot steel. The company got into financial difficulties, and the future of the completed portion of the works is uncertain.

Blast Furnaces at Sault Ste Marie

Building operations on the plant of the Algoma Steel Company, Limited, were begun in 1901. This company is owned by the Lake Superior Corporation of Sault Ste. Marie, Ontario, and in March, 1902, the first steel rails made in Canada were rolled at the Sault works. The original plans of the company called for four blast furnaces of 200 tons daily capacity each, a charcoal manufacturing plant to supply the blast furnaces, two 5-ton Bessemer converters and a rail mill with a capacity of 225,000 tons annually. The Bessemer and rail mill departments were built first and until the company's own blast furnaces were completed, steel was made from pig iron bought in the open market. Much iron was shipped from Midland for this purpose. During 1903 the whole of the Algoma Steel Company's plant was idle on account of the financial paralysis which fell upon all the great industries of Sault Ste. Marie in that year. In the year 1905 No. 1 blast furnace was blown in with charcoal as fuel. In five or six months, however, the supply of charcoal was exhausted, and coke imported from the United States had to be substituted. No. 2 blast furnace was blown in during 1906, coke being used in this furnace also. No. 3 and No. 4 furnaces have not been built as yet.

The ores used are almost exclusively of Lake Superior origin, no Bessemer ore being mined in Ontario in sufficient quantities to meet requirements, although several small shipments have been received from the Wilbur mine at Wilbur, Ontario.

Atikokan Iron Company, Port Arthur

The latest addition to the blast furnace plants of the Province is that of the Atikokan Iron Company, Limited, situated at Port Arthur on the north shore of lake Superior. The building of this furnace was started in 1906, and on July 17th, 1907, it was blown in with due celebration. This plant is of particular interest in that it produces iron from Ontario ore only. The mines of the company are 130 miles west of Port Arthur on the Canadian Northern railway, where the company owns extensive mining lands on what is known as the Atikokan Iron Range. The run of mine ore is high in sulphur, and is accordingly roasted in a modern roasting plant, blast furnace gas being used as fuel. The company have built coke ovens and manufacture their own coke from West Virginia coal imported for that purpose. The furnace was in operation but a short time during 1907, the management deeming it advisable, owing to prevailing conditions, to go out of blast until the spring of 1908.

Steel Furnaces at Welland

Another company that deserves mention is The Ontario Iron and Steel Company of Welland, Ontario. This company have erected basic open hearth furnaces, rolling mills and also a small steel foundry. The foundry department only is in operation, but

it is expected that the open hearth and rolling mill will be running this spring. Pig iron will be bought in the open market, and this section of the plant when operated will turn out rails, bars, angles, skelp, etc.

The Electro Metals Company, Limited, is also located at Welland, and the plant, although small at present, is very efficient and well laid out. At the present time it is manufacturing ferro alloys, such as ferro-silicon, ferro-chrome, etc., power being supplied by one of the largest electric power companies on the Canadian side of Niagara Falls.

By the time this report is printed it is expected that the company will be manufacturing pig iron by the electric process, using an improved form of the Heroult furnace. This is the first company in Canada organized for the purpose of manufacturing pig iron and ferro alloys by the electric process on a commercial scale, and its development and progress will be watched with much interest, not only in Ontario but by the world at large.

In February of this year the town of Campbellford granted a free site and 10 years' exemption from taxation to a group of American promoters who have agreed to install a $60,000 rolling mill.

Conditions for the Industry in Ontario

That the Iron Industry is growing in importance throughout Ontario cannot be doubted. At the present time there are seven blast furnaces in the Province, and two at least of the existing companies contemplate extensive additions to their plants in the near future. A large blast furnace and steel making plant is spoken of for Toronto, which will need over 1,200 tons of ore daily. This project is backed by the parties operating the Moose Mountain mine, and if carried to completion the works will be the largest in Ontario of their kind.

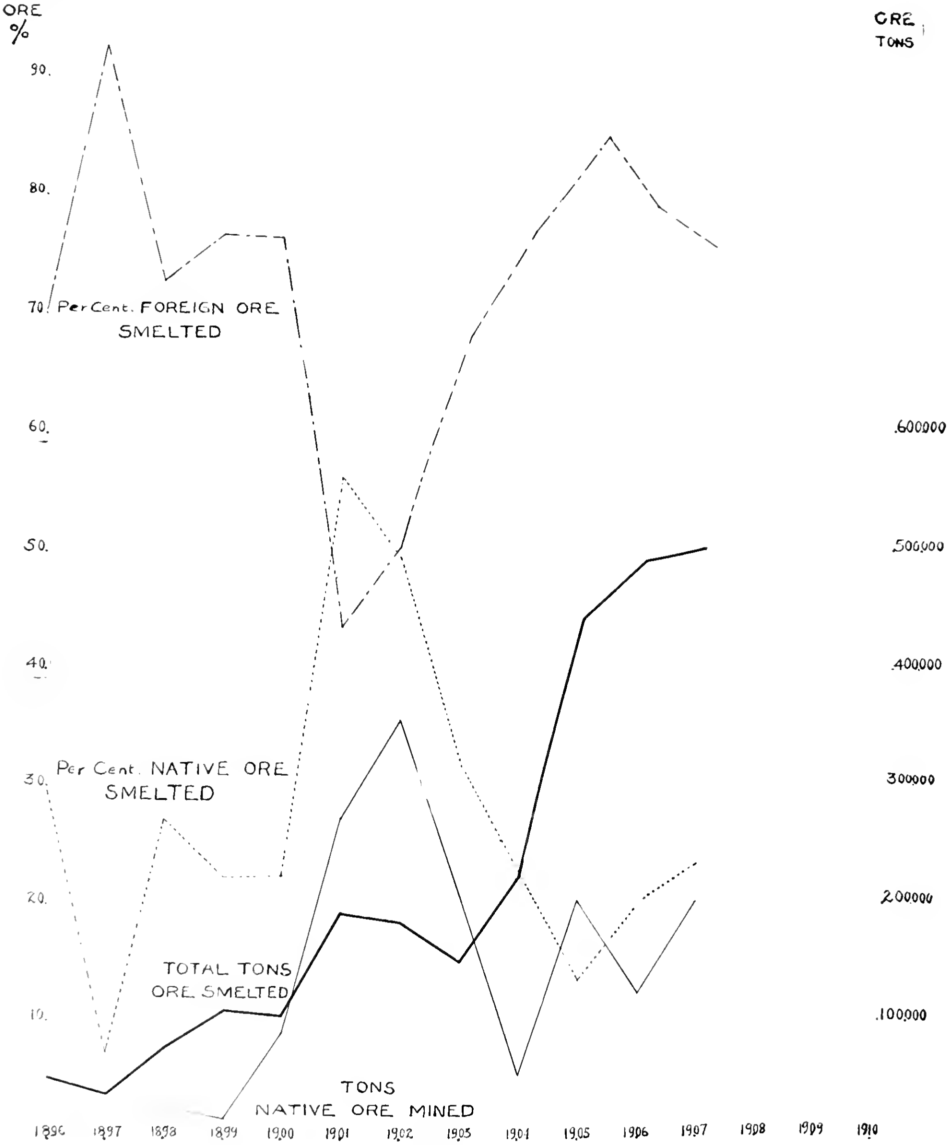
New deposits of valuable ore have recently been discovered, and it is within reason to suppose that other equally valuable finds will be made in the future. Millions of dollars have been expended in a systematic search for ore bodies upon all the older iron ranges of Lake Superior south of the international boundary. Nothing approaching this expenditure has ever been made in prospecting the iron formations of Ontario, and who knows what is contained in that vast and practically unexplored region between Lake Superior and Hudson Bay?

Unfortunately our greatest drawback in Ontario is lack of fuel. Charcoal has become too expensive except in remote districts, where the profits from cheap fuel would be swallowed up in transporting the iron to market. Of coal we have none, and must perforce either import coke or the coal for coke-making, from the United States. Under these conditions the building up of a flourishing iron industry presents some difficulties. At the 1907 Vienna meeting of The Iron and Steel Institute of Great Britain, Mr. Wilhelm Kestranck in a paper on the Austrian Iron Industry pointed out the natural influences that determine the growth of the iron industry of a country. He says:[1]

> It can be taken as an axiom that the development of the iron industry of a country, in relation to the consumption, depends more on the richness of its fuel resources than on an abundance of iron ore. Thus it is seen that countries such as Sweden and Spain, which are rich in ore and poor in fuel, export the greater part of their ores to countries rich in fuel, and are in proportion to their wealth in ore, only small producers of pig iron. Other countries, on the other hand, such as Great Britain, which depends to a large measure on the importation of iron ores, and Germany—which has also to import considerable quantities of ore—occupy a leading position. It is unnecessary to mention the happy United States, which rejoices in the possession of abundance of ore and of coking coal, and for this reason naturally occupies the leading position.

[1]Vienna Meeting of the Iron and Steel Institute: Electrochemical and Metallurgical Industry for October, 1907.

This again leads to another problem, which is the location of an iron works in respect to its sources of supply of raw material and distance from the market that takes its product. Professor Smith of the University of Pennsylvania has written the following, and what he has said may be taken as distinctly applicable to North America and to our own Province of Ontario in particular.[2]



Graphic illustration of the Iron Industry of Ontario from 1896 to 1907.

In the making of iron it is usually necessary for the fuel or the ore to be transported to some common meeting place, and in the working out of the problem of transportation the location of the iron industry has usually responded to the motto that 'the ore goes to the fuel', an example of this being the great movement

[2]The Story of Iron and Steel, by J. Russell Smith, see p. 65.

of Lake Superior ores to the Pennsylvania coal fields. *But it is not, however, a maxim of absolute sway.* The question is rather complex, and is to be answered by weighing various freight factors involved in getting the ore and the fuel to the furnace and the finished product to the market. It is therefore a triangular problem, and it sometimes works out to the moving of the fuel rather than of the ore. Examples of this are afforded by the present industry on Lake Champlain and in Northern New Jersey. Here are ore fields of excellent character; in both fields iron is being made with coke from Western Pennsylvania. The reason they can afford to break the maxim and carry the fuel to the ore is found by noting the disposition of the finished product. It goes to New England and the East, and the fuel is therefore *moving toward the final market of the iron.* In the same way, in the Pittsburg region, the ore from Superior has practically been travelling towards its market, which was in Pittsburg and the cities of the East. Latterly there has arisen a new iron industry on Lake Superior near that ore field. This industry is of comparatively small extent, and although it uses eastern fuel it will doubtless grow, because the market will be found in the rapidly developing Northwest.

It would seem, therefore, from the foregoing, that Ontario, with her rapidly growing manufacturing industries of all descriptions, can profitably import coke or coal for use in her iron industries, because the fuel is travelling in the direction of a market that is contained within the Provincial borders, and also the growing market of the great Provinces to the West.

At the present time we import large quantities of iron and steel from the United States and Great Britain, not necessarily because the foreign iron and steel can be laid down in Ontario more cheaply than it can be manufactured here, but because the demand for this material far exceeds the native supply.

Imports of Iron and Steel into Canada

It is not possible to obtain statistics showing the amount of foreign iron and steel imported into Ontario annually, but the total tonnage imported by the Dominion is given, and it may safely be assumed that Ontario consumes fully 40 per cent. of this amount.

	1905.	1906.	1907.	Totals
Iron and steel ingots, blooms, slabs, billets and puddled bars	317,829	650,943	383,003	cwt. 1,351,775 weight.
	$319,665	$663,794	$467,554	$ 1,451,013 value.
Steel rails	248,620	49,065	72,811	tons 370,496 weight.
	$5,533,523	$1,197,170	$1,867,865	$ 8,598,558 value.
Pig iron and cast scrap iron	84,506	103,410	165,591	tons 353,507 weight.
	$1,020,774	$1,455,071	$2,509,578	$ 4,985,423 value.

Production of Iron and Steel in Ontario

The following table shows the progress made by the pig iron and steel-making industry of Ontario since the revival of 1896, and also the proportions of native and imported ores respectively charged into the furnaces:

Year.	Ontario ore smelted, tons.	Foreign ore smelted, tons.	Limestone used, tons.	Coke used, tons.	Charcoal used, bushels.	Pig iron made, tons	Value pig iron, $	Steel made, tons.	Value steel made, $
1896	15,270	35,868	8,657	30,318	....	28,302	353,780	....	....
1897	2,770	34,722	9,473	27,810	....	24,011	288,128	....	....
1898	20,968	56,055	13,799	50,107	....	48 253	530,789	....	....
1899	21.494	85,542	25,301	74,403	....	61,749	808,157	....	....
1900	22,887	77,805	21,927	59,315	955,437	62,386	936,066	2,819	46,380
1901	109,109	85,401	51,452	113,119	915,789	136,370	1,701,703	11,471	347,280
1902	92,883	94,079	58,885	111,390	968,626	112,687	1,683,051	68,802	1,610,031
1903	48,092	103,137	49,426	96,540	933,620	87,004	1,491,696	15,229	304,580
1904	50,423	173,182	61,566	135,108	1,821,270	127,845	1,811,664	51,002	1,188,349
1905	61,960	383,459	121,052	262,415	3,387,869	256,704	3,909,527	138,387	3,321,884
1906	101,569	396,463	153,702	304,678	811,926	275,558	4,551,247	167,026	4,202,278
1907	120,156	388,727	171,037	326,937	1,849	286,216	4,716,857	170,632	4,168,137

II.—The Iron Ores of Ontario[3]

The mining of iron ore in Ontario has been and still is on a very small scale compared with the American side of Lake Superior, and any attempt to describe the iron ore industry of the Province must necessarily have in view the probable growth of this industry, rather than its achievements in the past.

Output Small Compared with U. S.

A comparison with the output from the great American mines may seem out of place, but it will serve to show the proportions to which mining operations in Ontario must grow if this Province is to take high rank in the production of iron and steel.

There are the same rock formations in northern Ontario as are found throughout the iron ranges of Michigan, Wisconsin and Minnesota, and they contain the iron series that are in many cases identical with those associated with the ore bodies of the American ranges.

Banded jaspers, magnetites and hematites occur for many hundred miles throughout northern Ontario, and when thoroughly and intelligently prospected will no doubt afford many valuable ore bodies. If the Americans are so far ahead of us in the production of iron ore, it is because they have spent more money in the exploration of one range alone than has been expended in exploring the whole of northern Ontario. The Americans, realizing this fact themselves, have of late years spent considerable sums of money prospecting the Ontario ranges. That success will attend their efforts is reasonably certain, and unless our ironmasters rise to the occasion and join in the search, they will be forced into the position of isolated buyers of native ores from American miners. At the same time we may be confident that the greater part of the output from these prospective mines will be exported to the United States and smelted in American furnaces.

Production of Iron Ore, Lake Superior Region

There is no other area in the world equal to the Lake Superior region as a producer of high grade iron ore. The only competitor is the minette region of Germany, France and Belgium, which is being rapidly left behind. The following table shows the great increase in production which has yearly taken place on the American side of Lake Superior.

1891	7,621,465	long tons.
1892	9,564,388	"
1893	6,594,620	"
1894	7,682,548	"
1895	10,268,978	"
1896	10,566,359	"
1897	12,205,522	"
1898	13,779,308	"
1899	17,802,955	"
1900	19,121,393	"
1901	20,593,537	"
1902	27,571,121	"
1903	24,281,575	"
1904	21,726,590	"
1905	34,241,498	"
1906	38,393,495	"
1907	41,817,385	"

But even the immense resources of the American side of Lake Superior will reach an end. The serious drain on this supply is well shown in the following quotation from Van Hise, one of the best authorities on Lake Superior iron mines:

[3]A good deal of the data contained in this section is from Mr. A. B. Willmott's paper on The Iron Ores of Ontario, read before the Canadian Mining Institute, Ottawa meeting, 1908, freely placed by Mr. Willmott at the writer's disposal. See Jour. C.M.I. Vol. XI.

The total product of the Lake Superior region since mining began in 1850 to 1899 inclusive is 171,418,984 long tons. The amount mined in the decade between 1891 and 1900 inclusive is 114,017,546 long tons, or 66.5 per cent., or nearly seven-tenths of the total amount mined. The product for the year 1900 surpasses that of any previous year, and is one-ninth of the aggregate of this and all preceding years. It is certain that the product of the current decade will far surpass that of the last decade.[1]

It is most striking that the production for 1907 is also one-ninth of the aggregate of this and all preceding years.

This season as a result of the investigation by the Tax Commissioner of Minnesota, it has been determined that the Minnesota deposits of ore approximate 1,170,000,000 tons. The total tonnage for the Lake Superior district of the United States, including undeveloped lands, amounts to about 2,000,000,000. This on the basis of last year's consumption will last fifty years, but as is shown in the preceding table, consumption is advancing with rapid strides. Already lower grade ores are being marketed than a few years ago was thought possible. In 1907 the standard for iron ore was reduced from 56.7 to 55 per cent. metallic contents, and this will undoubtedly continue as iron ore becomes scarcer. Moreover three-quarters of the ore reserves of Minnesota are in the hands of one company, and as the scarcity develops on the southern side, the search for ore among the iron formations in Ontario must correspondingly increase. Not only must part of the future demands of the United States be met from Ontario, but the Ontario demand itself must also be provided for. As shown in the accompanying table we only furnished last year 24 per cent. of the ore required for our Ontario furnaces. Indeed from 1901 and onward the proportion of Ontario ore used in our furnaces has steadily decreased.

Consumption of Iron Ore in Ontario 1896 to 1907

Year.	Foreign ore smelted, tons.	Foreign ore, per cent.	Native ore smelted, tons.	Native ore per cent.	Total ore smelted, tons.
1896	35,868	70.13	15.270	30.86	51,138
1897	34,722	92.62	2,770	7.38	37,492
1898	56,055	72.77	20,968	27.22	77,023
1899	85 542	77.74	24,498	22.25	110,040
1900	77,805	77.27	22,887	22.72	100.692
1901	85,401	43.89	109,109	56.09	194,510
1902	94,079	50.31	92,883	49.69	186.962
1903	103.137	68.19	48,092	31.81	151,229
1904	173.182	77.44	50.423	22.56	223,605
1905	383,459	86.10	61,960	13.90	445,419
1906	396.463	79.60	101,569	20.40	498,032
1907	388,727	76.30	120.156	23.60	508,883
Totals	1,914,440	Average, 73.80	670,585	Average, 26.20	2,585,011

Ores Mined in Ontario

In Ontario we have all the usual varieties of ores, hematite, limonite, and magnetite. But by far the largest production has been of hematite, namely about one and a half million tons.

Hematite

Hematite contains theoretically 70 per cent. iron. So far practically all the hematite produced has been from the Helen mine; considerable limonite is found intermixed, and the product of the mine would be strictly classed as brown hematite. The ores of the Frances and Josephine are hematites, but so far there has been no production. A slaty hematite occurs on the Williams property, a few miles north of Sault Ste. Marie. At Steep Rock west of Port Arthur, and at Loon Lake east of

[1] The Iron Ore Deposits of Lake Superior, p. 420.

Port Arthur, hematites have also been discovered. The specular variety occurs at Killarney, Algoma Mills, and Echo lake, also at the Stobie mine in Aberdeen township, from which a few small shipments have been made. Eastern Ontario has produced about 150,000 tons of hematite, chiefly from the Wallbridge, Dalhousie, and McNab properties, but all of these eastern deposits have proved to be small.

Magnetite

Of magnetite (theoretically, 72.4 per cent. iron), the Province has produced about 600,000 tons. Magnetite has been found in a dozen different localities in Eastern Ontario, and for the most part these ores with certain exceptions are high in iron, low in phosphorus and titanium, and high in sulphur. Along the Kingston and Pembroke railways several mines have been opened up and worked at various times. the chief producers being the Calabogie, Robertsville, Wilbur, and Glendower mines. The Wilbur is the only deposit worked at present. In the vicinity of the Central Ontario railway may be mentioned the Belmont, Blairton, Coe Hill, and the mines of the Mineral Range Iron Mining Company at Bessemer. The last mentioned are the only producers at present. The Radnor mine in Grattan township has been a steady producer in a small way for the past few years. In the northern part of the Province magnetites were mined last year, and will be shipped in increasing amounts. At Atikokan high sulphur ore is mined, and smelted in Port Arthur after preliminary roasting. Another promising deposit of magnetite a few miles west of Atikokan, has been explored and purchased by the United States Steel Corporation. This ore is said to run low in phosphorus and sulphur.

An extensive deposit of magnetite is being developed 25 miles north of Sudbury by Moose Mountain Limited; this property it is expected will soon make large shipments. Banded magnetites are found in the township of Boston, also in extensive ranges near Lake Nipigon and at Temagami.

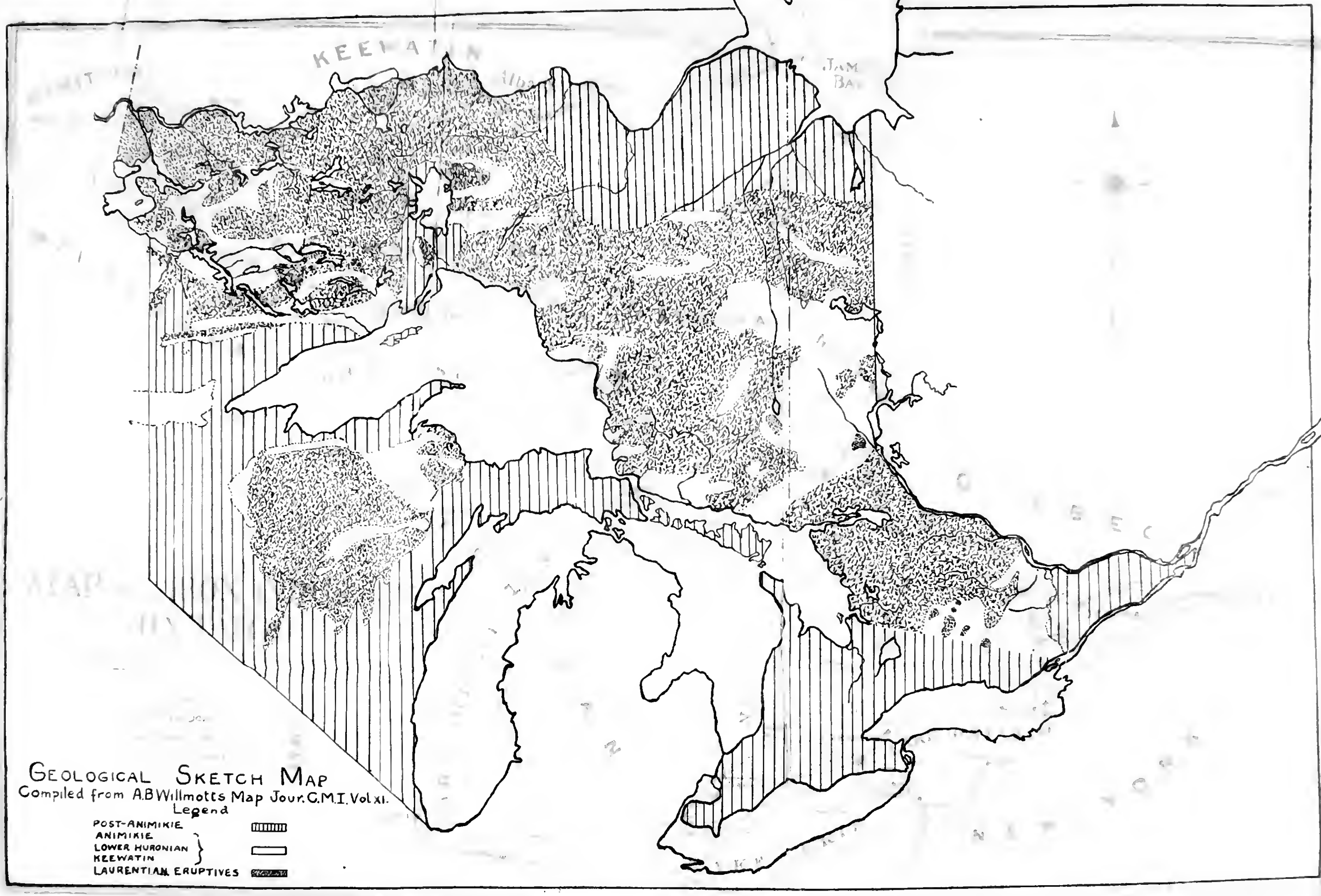
Titaniferous magnetites have been found in many localities and in bodies of considerable size, such as at the Chaffey, and Matthews mines on the Rideau canal. Another deposit occurs at Gooderham, and at Chapleau there is a very large ore body containing about 10 per cent. of titanium. In Hastings county the Orton mine carries from 1 to 3 per cent. of titanium. As a general rule, titanium is absent in Ontario magnetites except where the ore occurs in connection with basic eruptives. It is perhaps a little premature to state that these titaniferous magnetites are a valuable asset, but the fact remains that ores containing titanium in considerable amounts have been smelted in the past, although this does not seem to be realized by furnacemen, and no doubt means will be found to utilize these ores in future years.

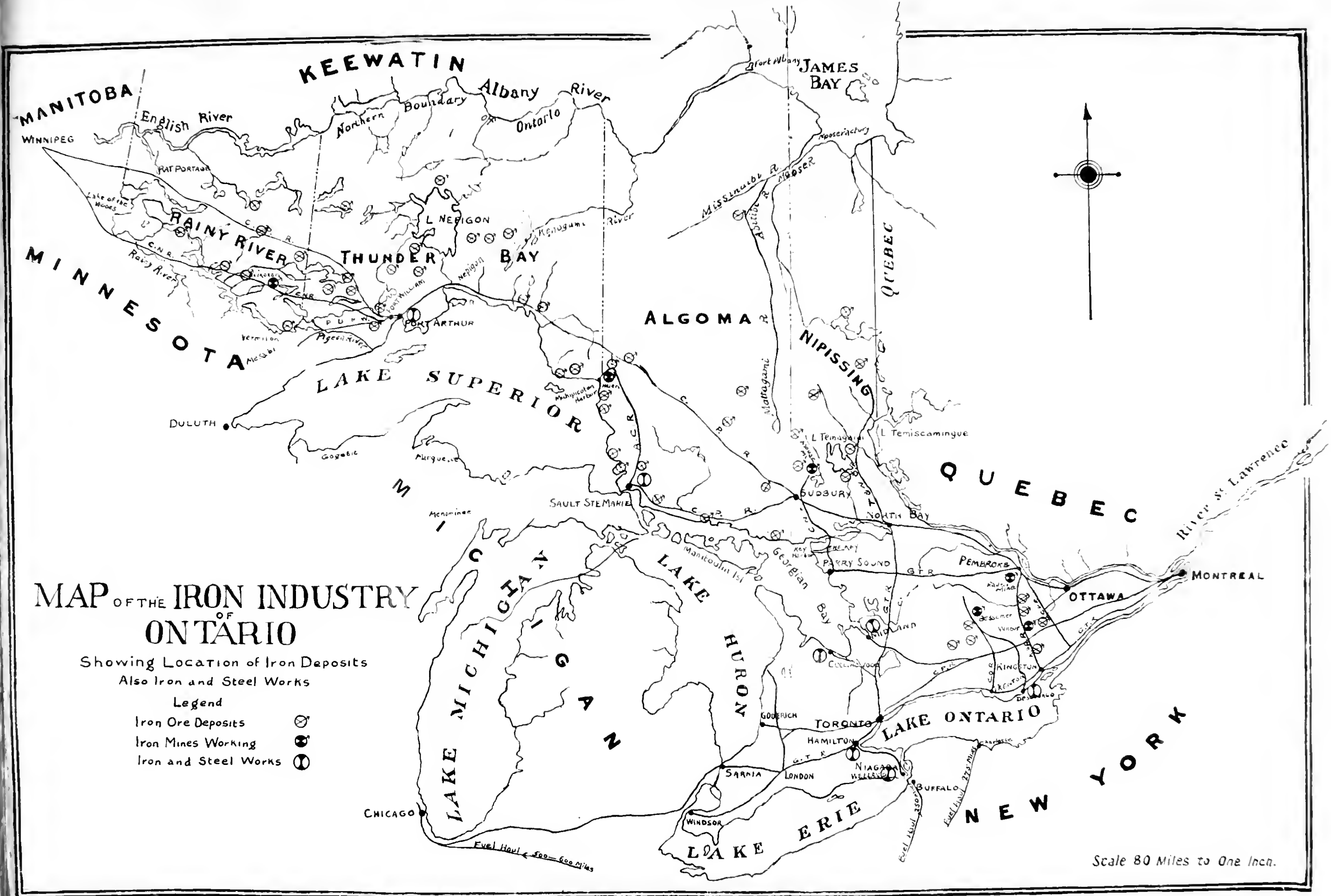
Bog ore

The bog or limonite ores of Norfolk county (theoretically, 59.8 per cent. iron), were smelted at various times in the first half of the last century, and similar ores from Oxford county have been smelted in small amounts at Hamilton. Ores of this class resulting from the oxidation of pyrites are found in western Michipicoten, and also at the Bannockburn pyrites mine. On the Mattagami and Moose rivers the oxidation of iron carbonates has resulted in bog ores running 48 to 57 per cent. in iron, about 1 per cent. in sulphur and from 0.1 to 0.2 per cent. in phosphorus.

Siderite

Siderite (theoretically, 48.2 per cent. iron) is found in Ontario in connection with numerous hematite deposits, notably on the hill at the back of the Helen mine, at the Josephine, at Steep Rock lake and at other points. At the Helen mine the siderite will average 34.94 per cent. iron with 7.7 per cent. insoluble, but in all cases is usually contaminated with sulphur in amounts varying between 1 and 2 per cent.


KEEWATIN
JAMES BAY
GEOLOGICAL SKETCH MAP
Compiled from A.B Willmotts Map Jour. C.M.I. Vol XI.
Legend
POST-ANIMIKIE
ANIMIKIE
LOWER HURONIAN
KEEWATIN
LAURENTIAN ERUPTIVES


MAP OF THE IRON INDUSTRY OF ONTARIO
Showing Location of Iron Deposits
Also Iron and Steel Works
Legend
Iron Ore Deposits
Iron Mines Working
Iron and Steel Works
Scale 80 Miles to One Inch.
KEEWATIN
MANITOBA
WINNIPEG
English River
Albany River
Northern Boundary Ontario
JAMES BAY
Fort Albany
Moose Factory
Missinaibi R.
Moose R.
Abitibi R.
RAT PORTAGE
Lake of the Woods
RAINY RIVER
Rainy River
L. NEPIGON
Kenogami River
THUNDER BAY
PORT ARTHUR
FORT WILLIAM
MINNESOTA
Vermilion
Mesabi
Pigeon River
ALGOMA
NIPISSING
QUEBEC
Mattagami
LAKE SUPERIOR
DULUTH
Gogebic
Marquette
Michipicoten Harbor
Helen
A.C.R.
C.P.R.
L. Temagami
L. Temiscamingue
SUDBURY
NORTH BAY
SAULT STE MARIE
Menominee
MICHIGAN
LAKE MICHIGAN
CHICAGO
Fuel Haul 500—600 Miles
Manitoulin Isl.
Georgian Bay
LAKE HURON
PARRY SOUND
G.T.R.
PEMBROKE
OTTAWA
MONTREAL
River St. Lawrence
MIDLAND
COLLINGWOOD
KINGSTON
DESERONTO
GODERICH
TORONTO
HAMILTON
LAKE ONTARIO
SARNIA
LONDON
NIAGARA
WELLAND
BUFFALO
Charlotte
Fuel Haul 275 Miles
Fuel Haul 250 Miles
WINDSOR
LAKE ERIE
NEW YORK

Magnetic Sands

Iron sands have been and are being concentrated at many points in the Province by the waters of the great lakes. A deposit of these sands is found close to Peninsular Harbor on the north shore of Lake Superior, and on the north shore of Lake Erie these sands have accumulated and were smelted in the old Normandale furnaces nearly 100 years ago.

Geological Distribution of Ores

The geological formations occurring in Ontario, beginning at the most recent, may be classified as follows:—

Cenozoic	Recent.		
	Glacial.		
Paleozoic	Devonian.		
	Silurian.		
	Cambrian.		
Proterozoic	Keweenawan or Nipigon		
	Huronian	Upper	
		Middle	
		Lower	Hastings.
(Pre-Cambrian)	Laurentian (granite and gneiss)		Grenville.
	Keewatin (greenstone, etc.)		

In the Pleistocene (or, Recent and Glacial) we have only insignificant deposits of bog ores. In the Devonian there are some siderite deposits in the valley of the Moose river, of little commercial value. The Silurian is also barren of valuable ores. At the base of the Potsdam of the Cambrian there are some impure hematites found at Dog Lake north of Kingston, and at the base of the Keweenawan are found ocherous clays, but of no value commercially as iron ores.

The Animikie presents possibilities of finding valuable ores, and it is this formation which carries the Mesabi, Gogebic, and Menominee ranges on the American side of Lake Superior. It is found in Ontario in the triangular area bounded by Lake Superior, the United States boundary, and a line extending from Gun Flint Lake northeasterly to Thunder Bay. Indications of ore have been found at numerous points in this area, and at Loon Lake east of Port Arthur ore bodies have been developed. Near Sudbury is another Animikie area, but so far is not known to carry iron ores These two areas represent the known extent of the Animikie in Ontario.

The Lower Huronian is widely distributed throughout Ontario, but so far little iron ore of commercial value has been discovered in this formation, although in Deroche township, north of Sault Ste. Marie, prospecting has met with fair success, and some specular hematite is found in Long and Rutherford townships. In Aberdeen township a more promising prospect is met with.

In the Keewatin the most promising of the iron deposits of Ontario are found. The formation is widely distributed, and in nearly every place where Keewatin or Huronian areas are marked on the geological maps, bands of iron formation have been discovered. Usually these bands are only a few hundred feet wide, almost always less than half a mile. Frequently there are a series of lenses in a row or arranged in parallel rows. At times the iron belt extends for many miles, being enclosed on either side by green schists.

The ores from the various producing mines on the American side are found in the Keewatin, Huronian and Animikie series. These formations occur in narrow

belts between the eruptive granites just as in Ontario, and the association of banded jasper with ore is characteristic on both sides of the lake.

In the following table the total production of the several ranges in the Lake Superior region is given:

Range.	Year Opened.	Tons Shipped.	Shipments Per Cent.
Marquette	1855	84,849,280	22.3
Menominee	1877	63,806,652	16.7
Gogebic	1884	54,023,478	14.2
Vermilion	1884	26,785,950	7.0
Mesabi	1892	150,198,054	39.4
Ontario	1900	1,361,000	0.4
		381,024,414	100.0

The Ontario production is made up mainly of shipments from the Helen mine on the Michipicoten range and the Atikokan mine in the District of Rainy river, both of which are in the Keewatin formation, as are also the mines in the Vermilion.

The mines of the Menominee, Gogebic and Mesabi are all in the Animikie, and most of the Marquette production comes from the Lower Huronian, although a portion of it lies at the base of the Animikie, practically at the contact with the Lower Huronian. Assuming that the whole of the Marquette production is from the Lower Huronian one finds that, of the total production of iron ore from around Lake Superior, 70.3 per cent. has been produced from the Animikie, 22.3 from the Lower Huronian, and 7.4 from the Keewatin.

Genesis of Iron Ores

To quote Mr. Willmott:

As previously stated, the majority of the Ontario ores occur in the Keewatin formation. At the base of this series is a mass of greenstone, frequently ellipsoidally parted, which is the oldest known rock of the Lake Superior area. Overlying this are various green schists, and towards the top of the series the Iron formation proper. This consists of ferruginous cherts, more or less banded with hematite and magnetite, iron carbonate and iron pyrites. Carbonated schists frequently border the Iron formation. Originally these belts seem to have been a chemical sediment, but are now found in nearly every case closely folded, and standing nearly vertical. Transverse folding has been a very common occurrence, and the anticlines have been frequently eroded until the formation has been cut off into lenses, varying from a few feet to a few miles in length. In most cases the width of the formation is a few hundred feet, and occasionally up to half a mile. Folded with the Iron formation there is usually a bed of green schists which form an impervious layer at the bottom of the basin. The American geologists who have closely studied the Vermilion and other south shore ranges, are of opinion that the ores associated with these ranges have resulted from descending waters concentrating the leaner ores from above, in the bottoms of these basins. Iron carbonate is supposed to have been the most frequent source of the ore, but both iron silicate and iron pyrites have also contributed. Probably in our Ontario ranges iron pyrites is a larger contributor than in the ranges to the south. In some few cases the original deposits in connection with the formation seem to have been rich enough to make an iron ore without further concentration. In other cases there are lean silicious magnetites up to 40 and 45 per cent. in iron, which can hardly be classed as commercial ore bodies, and which might well represent original deposits without secondary concentration. In these the silicious bands are absent, the silica being more evenly distributed through the whole mass. Another class of ore bodies includes those which are regularly banded, consisting of either hematite or magnetite alternating in narrow bands from one-eighth of an inch to 2 inches in width, with bands of quartz which may be white and gray chert, or red or black jaspers. It is with the more granular cherts that the hematite ore bodies so far discovered have been found.

Iron Ore Mining in Ontario

The production of iron ore in Ontario from 1898 to 1907 is shown in the following table:

Schedule	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907
Ore Shipped ....tons	27,409	16,911	90,302	273,538	359,288	208,154	53,253	211,597	128,049	205,295
Value ....$	48,875	30,951	111,805	174,428	518,445	450,099	108,068	227,909	301,032	482,532

There are in Ontario six producing iron mines at the present time. Only one of these, however, the Helen, is worked on a large scale, and another promising large producer, Moose Mountain, has but recently commenced mining operations.

The Helen mine stands alone as our single producer of hematite. The other five are all mining magnetite, and so far the total production from the magnetite mines does not amount to one-half that obtained from the Helen. This fact is due in part to the character of the Helen ore deposit itself, which is a large body of high grade ore easily mined within reasonable cost, and partly because the magnetite ores with the exception of Moose Mountain, have usually been found in smaller ore bodies, generally contaminated with more or less deleterious matter, such as pyrites or gangue rock, which necessitates either sorting at the mine, or preliminary roasting before being smelted in the blast furnace.

With the opening up of Moose Mountain a change in the relative amounts of hematite and magnetite produced may be expected within the next few years. The cost of winning these magnetites will in most cases be higher than of the hematites, although certain exceptions may be cited where large bodies under favorable circumstances have permitted mining at a low cost. The magnetites of the Cornwall district in Pennsylvania are, it is stated, mined for 30 cents a ton. This is of course exceptional, and can only be accomplished with careful management aided by natural conditions.

Features of a Profitable Iron Mine

A deposit of iron ore to be worked at a profit should possess several essential features that are as a rule not required by the ore deposits of the higher priced metals. First, the ore should be reasonably pure, containing at least 50 per cent. of iron (with certain exceptions), and uncontaminated with injurious elements that would be prejudicial to its economical smelting in the blast furnace. Secondly, the deposit should be large enough to admit of economical mining, by removing the ore without handling any undue proportion of waste rock; and as the richest and purest ores are not worth more than \$4 to \$5 a ton delivered at the furnace, it can be seen that the amount of waste handled should be kept within narrow limits. Thirdly, there must be facilities for economically transporting the ore by rail or water, the length of transportation being governed by the freight rates, but so that the total cost of the ore at the furnace will allow the manufacturer a reasonable profit on the pig iron produced. And fourthly, the mine should be under careful and capable management, using modern methods of mining, and keeping the output at the highest possible point. All of the first three conditions may obtain, pointing to the successful operation of the deposit, and yet if the fourth is neglected, mining operations may result in failure and disaster.

Eastern Ontario has witnessed many attempts in mining the magnetites that are so abundant throughout that district, but as a general rule these mining ventures have not met with much success; in some cases because the deposits are either associated with sulphur, or are so intimately mixed with rock matter that the ore is undesirable from a furnaceman's point of view. In others, because the

owners or operators have failed to realize the fact that an iron mine to be successful must be managed with rigid economy and at the same time worked on a scale that will keep mining costs within reasonable limits.

Low Grade Deposits

In the mining of low grade deposits, where the ore must be sorted or hand-cobbed to separate gangue matter, it is impossible to keep the costs down to the same level as when mining high grade ores. But if in the case of low grade magnetites the ore is submitted to a preliminary treatment, such as magnetic concentration, and subsequently to briquetting or nodulizing, the problem of mining is much simplified. Sorting is avoided entirely, and the general run of mine as low as 30 per cent. in iron can be sent direct to the separating mill, provided always operations are conducted on a sufficiently large scale to enable mining costs to be kept at a low

Martell mine, near Calabogie, showing old head frame.

figure. For instance, it would not be profitable to concentrate a 30 per cent. ore that was costing $1.50 a ton to mine, because it would take 2.5 tons of crude ore costing $3.75 to make one ton of concentration at 60 per cent. iron, allowing for a probable loss of 10 per cent. of iron in the tailings. But if that ore can be mined and delivered to the mill for 75 cents a ton the process would have every chance of proving profitable.

There are numerous deposits in this eastern section of the Province that afford opportunities for concentration. On the Kingston & Pembroke railway the most notable are those of Calabogie, Robertsville and Glendower. These mines have all been operated at one time or other, but work has been abandoned for some years, owing to the fact that the ore was too high in sulphur, or contained too small a percentage of iron. Similar deposits are found in other localities along the railroad.

On the Central Ontario railway low grade deposits exist at Coe Hill, Belmont and Blairton. Large bodies of low grade ore are also found on the property of the Mineral Range Iron Mining Company five miles east of L'Amable station.

It is doubtful if any one of these deposits in its present undeveloped state could supply a large concentrating mill, but by erecting a plant in some favorable locality, where cheap hydro-electric power could be developed, and within reasonable distance of the mines, enough ore could be obtained by the combined outputs from several of the different deposits, to supply the separating mill with 1,000 tons daily. A mill with much less capacity than this would not be found economical, because the process of magnetic separation is expensive when compared with the value of the concentrated product.

The Producing Iron Mines of Ontario

Following is a brief account of the iron mines at present in operation in the Province, beginning with the west, and proceeding to the east.

The Atikokan Mine

The Atikokan iron deposits were discovered in 1882 by an Indian trapper who informed his employer of the find. The latter in turn interested Messrs. McKellar Bros. of Fort William, who applied for and acquired from the Government what is now known as Locations E 10 and 11.

In 1905, the property was acquired by the Atikokan Iron Company, with William Mackenzie president, and J. C. Hunter of Duluth vice-president and general manager. An agreement was entered into with the town of Port Arthur whereby the company agreed to put up a roasting plant and blast furnace in Port Arthur, in return for certain concessions from the town in the way of site and cash bonus.

The mine is situated 128 miles west of Port Arthur on the Canadian Northern railway. A spur line three miles long connecting the mine with the main railroad has been built, making a total rail haul of 131 miles from the mine to the furnace.

The ore occurs in a ridge of chlorite-schist[5] striking E and W across the swamp for a distance of 4,000 feet. The ridge will average 100 feet high and is 280 feet wide at its base. Parallel bodies of magnetite standing almost vertical follow this ridge along its longer axis, and can be traced on the surface throughout its length.

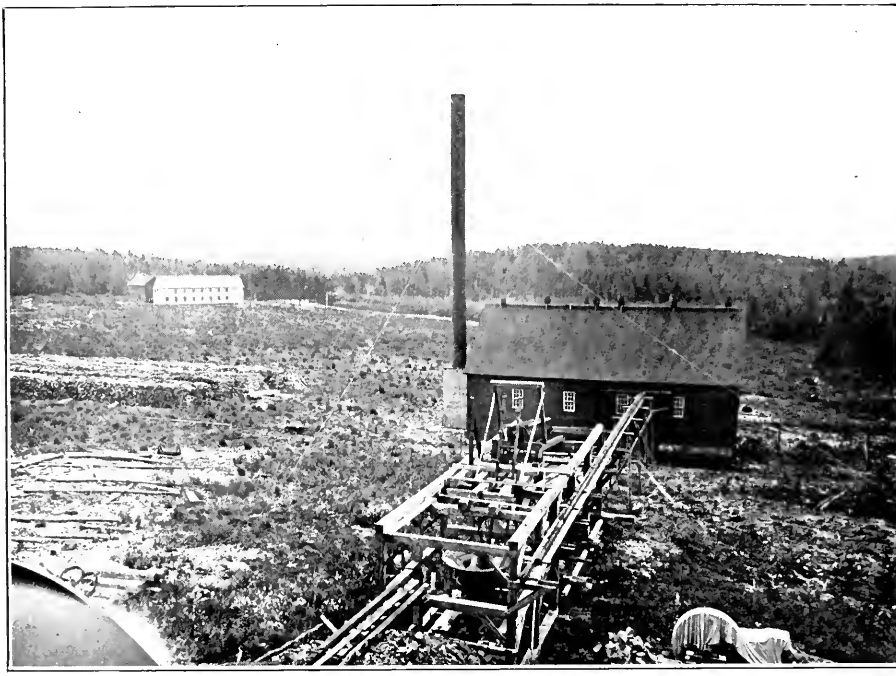
The ore is partly fine and partly coarse grained magnetite, running 60 per cent. in metallic iron. It contains pyrrhotite and pyrite to such an extent that the run of mine will average 2.5 per cent. in sulphur, and hence must be roasted before smelting in the blast furnace. Phosphorus is contained to the amount of 0.162 per cent., which places the ore on the non-bessemer list.

The accompanying sketch shows the relative position of the ore bodies, and gives some idea of the extent of mining operations.

At the base of the hill a tunnel 6 feet wide has been driven clear through to the other side, cutting ore at A. 40 feet wide, ore at B. 10 feet wide and ore at C. 16 feet wide. The width of this tunnel was afterwards increased to 12 feet, from the 40-foot ore body to the tunnel mouth.

Deposit A. is the only one being worked at present. It has been stoped out to a height of 20 feet, and driven 85 feet to the east and 65 feet to the west. Upraises have been started at both ends; that at the west end is up 50 feet. The intention is to continue this raise through to the surface, and then work back towards the tunnel, understoping the ore. At the east end, the raise is within a few feet of a surface open cut; this will be broken through, and the ore then worked out from both sides. No timbering is required in the stopes, as the ground is very hard and requires no holding.

[5] Bur. Min. Rep. Vol. XII, (1903), p. 306.



Atikokan iron mine; power house, crushing and loading machinery. Boarding houses in distance.

Atikokan iron mine; power house, store house, dry and smithy.

Deposits B. and C. are both smaller than A., and the ores not so massive, having more of a schistose structure, but on analysis they prove to be lower in sulphur and higher in lime than A.

Several bore holes have been put down at different times to prove the property, and considerable ore is said to have been struck in most of them. Five of these holes were put down on the south side of the ridge, three at an angle of 45 degrees and two horizontal. One angle hole was drilled from the north side of the ridge.

The ore is trammed out of the tunnel in 1½ ton cars, and fed to a No. 6 Austin gyratory crusher, capacity 50 tons per hour, which delivers to an 18-inch belt elevator, conveying the ore in 12 x 18-inch buckets and elevating to 30 feet, where it is dumped direct into 50-ton drop bottom steel cars. No storage pockets are used, but a string of empty cars are kept spotted on the mine siding and allowed to run by gravity down to the elevator as required. With this equipment 200 tons of ore are shipped per day of ten hours.

Analysis of the run of mine ore is said to be as follows:—

Fe.	SiO_2	Al_2O_3	P	Mn	CaO	MgO	S.
62.14	7.64	0.75	0.12	0.09	2.54	2.18	1.04

Power for the crusher and elevator is supplied by a 50-h.p. Jenckes engine situated in the crusher building.

The main engine room 40 x 70 feet contains three 100-h.p. return tubular boilers, the high pressure half of a Canadian Rand Air compressor, class B. 3, supplying 2,670 cubic feet of free air per minute at 80 lbs. pressure, steam pressure at 125 lbs.; the foundation for the low pressure side of the compressor is in place. A 750-h.p. Wainright heater and a Fairbanks boiler feed pump complete the equipment; water suction is direct from the Atikokan river 200 feet away. It is the intention to install a 150-light electric plant at an early date.

Other mine buildings are a dry house and blacksmith shop each 20 x 40 feet, two large commodious frame buildings 60 x 27 feet, used for boarding and bunk houses for the staff and miners. These will accommodate 100 men easily, but not more than 65 men have been employed at any one time to date.

At the time of my visit the mine was shut down owing to the fact that the furnace in Port Arthur was out of blast. Mining operations are likely to be resumed in the spring of 1908 and will probably be carried on on a more extensive scale.

The superintendent of the mine is Mr. F. Rodda, to whom thanks are due for courtesies received during my visit.

The Helen mine

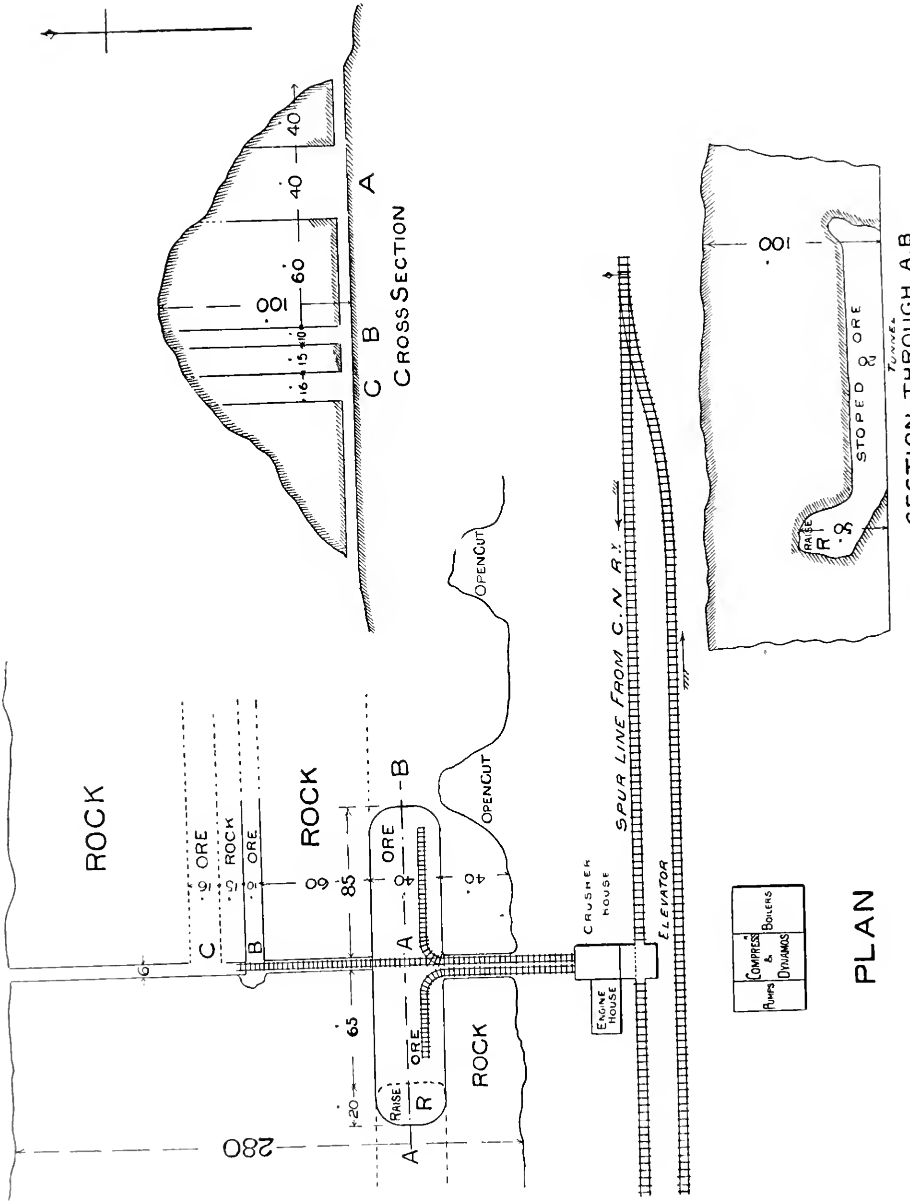
The Helen mine in the Michipicoten district is the largest single producer of iron ore in Ontario to date. Controlled and operated by the Lake Superior Corporation, this deposit has been developed along lines comparable with the large iron mines of Michigan and Minnesota, and is producing ore at the rate of 1,000 tons daily.

The mine, situated 12 miles from Michipicoten Harbor, is connected with that shipping point by a branch line of the Algoma Central and Hudson Bay railway. The ore is shipped from the mine in 50-ton steel ore cars and delivered to the dock pockets, from which it can be chuted into the holds of vessels alongside, at the rate of 800 tons per hour. There is 24 feet of water at the docks, so that the largest ore freighters can be loaded. During the closed season of navigation the ore is stocked at the mine.

Helen ore is a mixture of hematite and limonite, and according to Mr. R. W. Seelye[6] may be described as follows: First grade, hard compact red hematite, 60 per cent. iron and over, the second, porous but hard brown limonite, 57 to 58 per cent. iron, the third, soft brown limonite, 53 to 54 per cent. iron. The ore contains too much phosphorus to be classed as Bessemer, but sulphur is within reasonable limits, despite

[6]Bur. Min. Rep., Vol. 14 (1905), p. 60

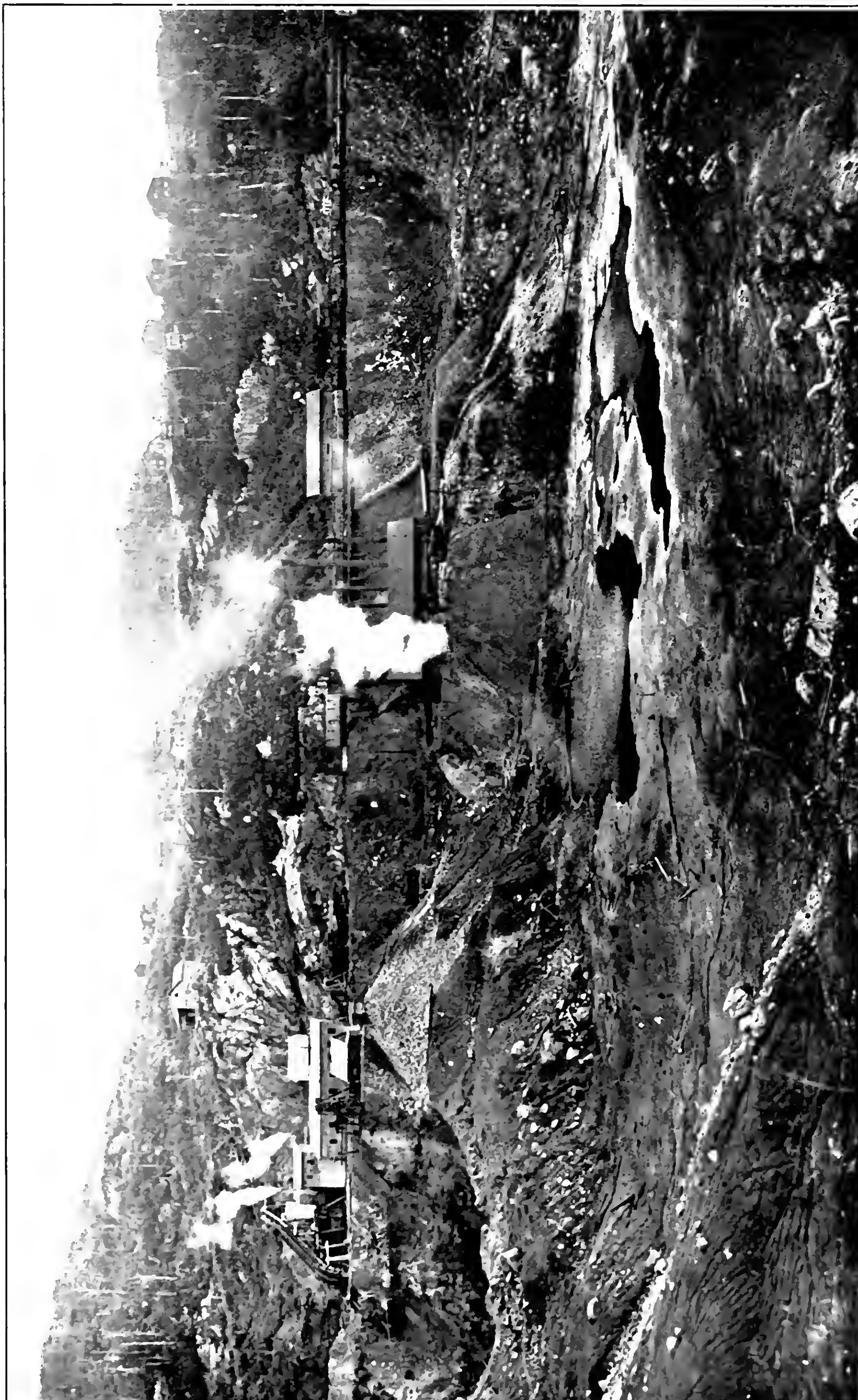
the fact that much nodular pyrites is found throughout the deposits, although from the character of its occurrence it can easily be avoided. Iron pyrites is found in considerable quantities under the old bed of Boyer lake, and several shipments have been made to the Company's sulphite works at Sault Ste. Marie.



Sketch plan of Atikokan iron mine.

The following analysis of Helen ore was obtained from the Hamilton Steel and Iron Company, and is representative of the stock piles of this ore at the blast furnaces.

Fe.	SiO_2	Al_2O_3	P	Mn	CaO	MgO	S	Moisture.
57.10	5.27	1.04	0.128	0.038	0.20	0.10	0.053	3.44



Helen iron mine, 1906, showing the original bed of Boyer lake.

From a blast furnaceman's point of view the ore is an ideal one for manufacturing foundry iron. The proportion of lump ore to fines is high enough to prevent undue waste in flue dust, and the physical character of the ore is such that it admits of easy and rapid reduction. If it were not for the presence of phosphorus in amount exceeding the Bessemer limit, the ore would be classed with the best of the Lake Superior Bessemer ores.

The iron formation[7] at the Helen mine has a total length of one and three-quarter miles and is over nine hundred feet wide, consisting for the most part of ferruginous cherts, banded cherts and iron ore, and cherty siderites, containing the iron ores proper, hematite and limonite, also considerable pyrite. This formation striking nearly east and west, lies in Wawa tuffs belonging mainly to the Lower Huronian. These rocks consist of greenish or brownish schists containing much silica and sericite as well as carbonate in some cases. The "Gros Cap" greenstones outcrop along the margin of the Iron formation. These rocks, according to Van Hise, are the oldest in the Lake Superior region. The ore body itself lies at the eastern end of Boyer lake, and is surrounded on the three sides by steep and high hills and on the west by Boyer lake. This was originally a pond about one-quarter of a mile long and hardly as wide, with a depth of 133 feet, but has been pumped out to permit of mining under the lake bed.

The highest point at which ore is found is 100 feet above the lake, and as drill holes have proved the ore to a depth of 188 feet below the original surface of the water, the total thickness of the deposit is in the neighborhood of 288 feet.

From the edge of Boyer lake the ore body extends eastward for 1,400 feet with an average width of 400 feet, and it is this main deposit which has been worked so extensively the past few years.

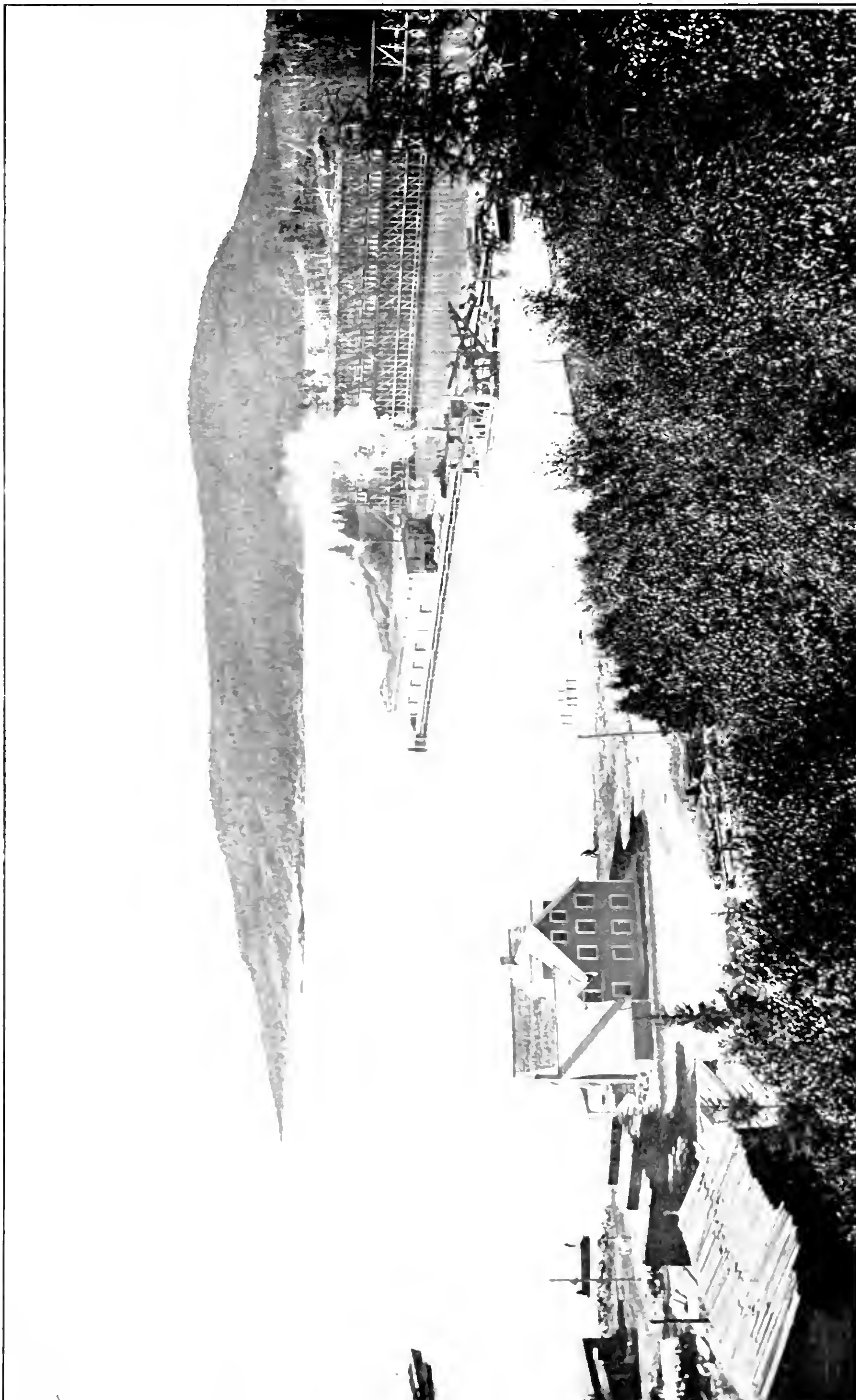
During the early years of development the mine was worked in open cut benches, breaking down the ore by heavy blasts and loading with steam shovel. A Lidgerwood cableway was also erected over the ore body, and handled that portion which was inaccessible to the steam shovel. This system of mining was replaced later on by underground development, and at the present time all ore is mined from beneath the surface.

Two vertical shafts[8] have been sunk 100 feet apart in the greenstone along the southern edge of the ore body. No. 1 is a double compartment shaft with cage, pipeway, and ladderway, and is used as a man entry, also to convey timber and other supplies below the surface and for the hoisting of waste rock. No. 2 is a double compartment shaft also, and is used entirely for hoisting ore. Both shafts are about 300 feet deep, and are connected at the bottom by a drift 100 feet long.

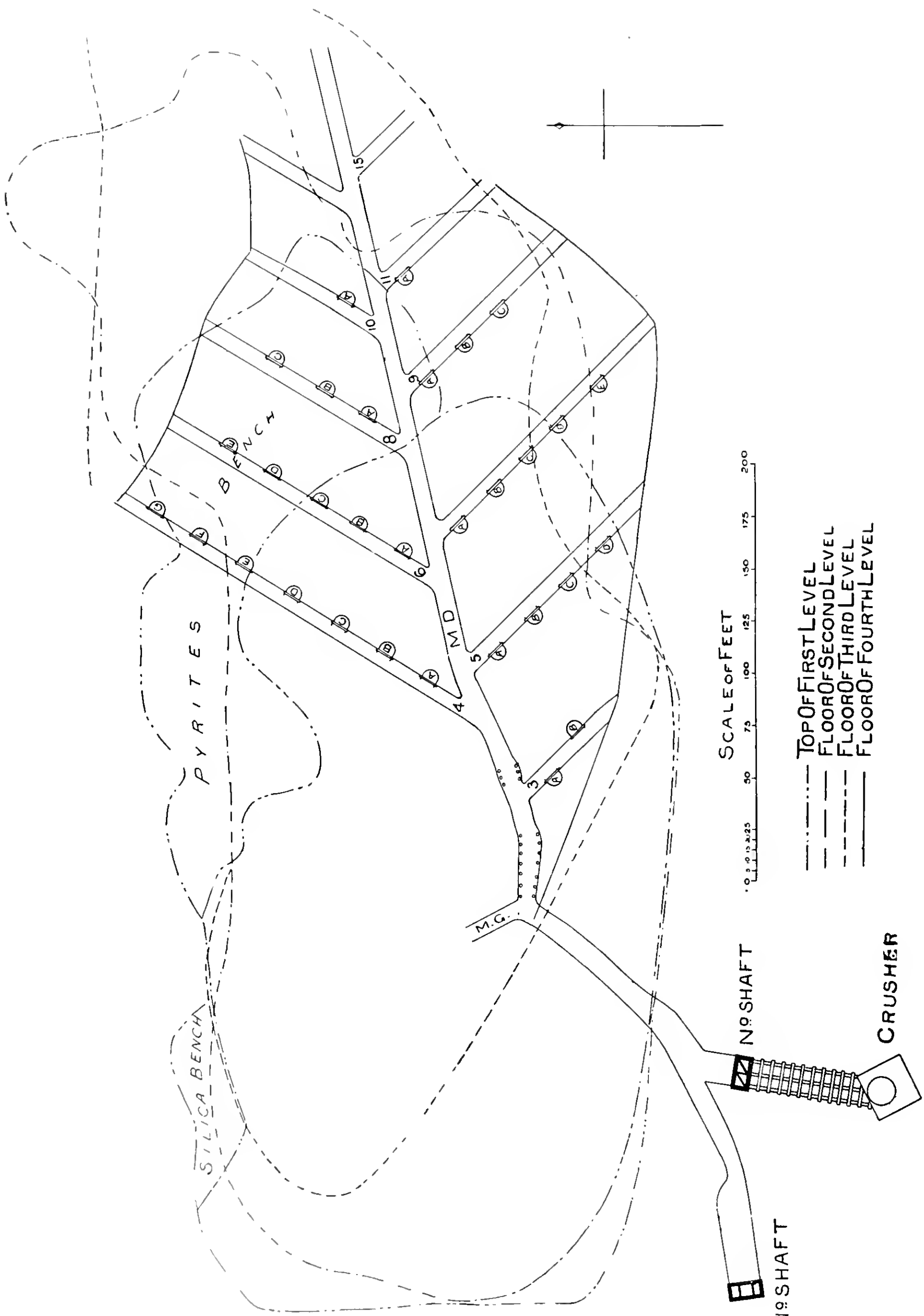
From the bottom of No. 2 shaft a cross-cut 11 feet wide is driven 150 feet to the ore body and continued through the deposit to the northern boundary of merchantable ore, a distance of 250 feet. From the point where this cross-cut meets the ore a main drift has been driven 500 feet, following the ore to its eastern boundary, and from this main drift auxiliary cross-cut levels approximately northeast and southwest are made every 50 feet, running to the boundaries in each case. Upraises are made in these cross-cuts every 40 feet, and are driven to within 20 feet of the levels above, chutes are put in at the bottom of each upraise, and the ore is broken down by overhand stoping connecting adjacent upraises as the ore is removed. The stopes are not more than 60 feet high, and are worked out from the boundaries of the ore body, back towards the main tramway drift.

The lake pump is used to pump out Boyer lake adjoining the mine workings, thus keeping the water from running through to the mine workings and making it necessary to pump the water to the surface. This pump is a single cylinder Cameron 16x16x18 inch having a 10-inch suction and 8-inch delivery pipe. The pump raises 470 gallons of water per minute against a head of 75 feet.

[7] The Michipicoten Iron Region, by A. P. Coleman and A. B. Willmott, Bur. Min. Rep. Vol. 11 (1902), p. 152 *et seq*
[8] Bur. Min. Rep., Vol. 16 (1907), p. 72.



Michipicoten Harbor, 1906, showing docks from which Helen ore is shipped.



Plan of Helen iron mine.

The underground workings are kept free from water by means of pumps placed on the second, third and fourth levels. There are six pumps used for this and a seventh used for shaft sinking.

The ore is raised by a double 5-foot drum hoist of 2,000 tons daily capacity, and is dumped direct from the 4-ton Kimberley skips to a No. 8 Gates style D gyratory crusher which can handle 2,500 tons per day, crushing to six inches. It is then shipped to Michipicoten Harbor.

The power house contains two Ingersoll-Sargent single stage air compressors of 12 and 5-drill capacity respectively, and five large horizontal boilers of the fire tube type, 640 horse power combined, supplying steam for the whole plant. A feature of the plant is the absence of feed pumps, the water being fed to the boilers at a pressure of 140 pounds, caused by the difference in elevation between the boiler plant and the lake where the water is obtained.

During nearly the whole of 1903 the mine was shut down, consequent upon the financial difficulties which beset the Lake Superior Corporation in that year, and in the summer of 1906 another shut down of two months was caused by fire destroying the shaft house, power plant, crusher house and other buildings. Since that time the mine has been producing steadily, and has yielded from 1899 to 1907 over one and one-third million tons of merchantable ore.

Moose Mountain, Limited

Moose Mountain is situated about 25 miles north of Sudbury in the township of Hutton. The Company control 4,600 acres of mining lands, all in Hutton, and up to date have proved the existence of several large bodies of iron ore, chiefly magnetite with a little hematite. The accompanying sketch map of Hutton township shows the extent of the company's property, and the location of the various ore bodies.

The ore occurs in the Keewatin rocks,[9] consisting mostly of geenstones, the oldest series of rocks known in this part of the continent. The ore is a very fine grained magnetite, hard and crystalline, but easy to crush, and according to the proportion of silicious or amphibolitic material which it contains, will vary from lean to high grade.

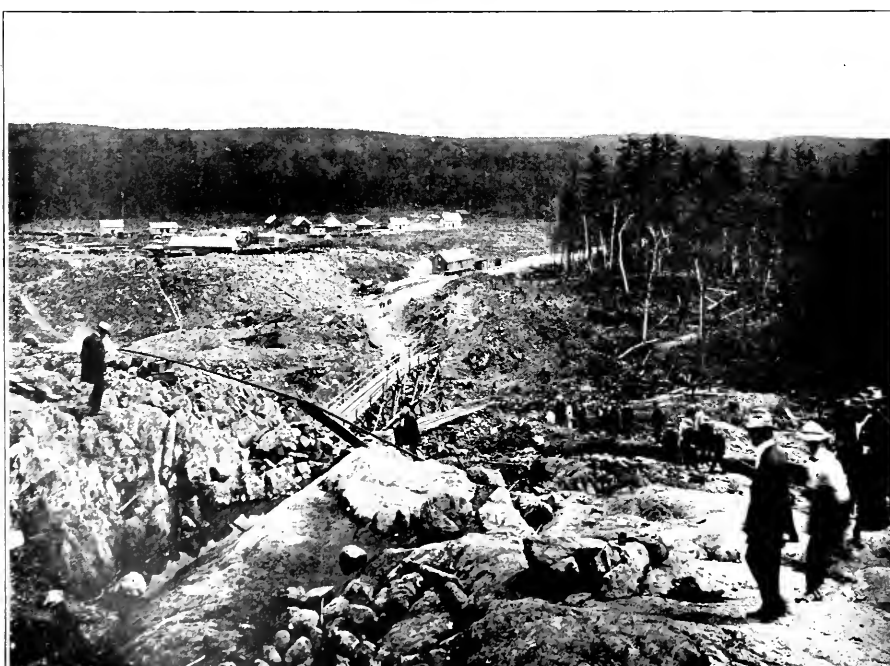
No. 1 deposit is approximately 500 feet long and 150 feet wide. It has been proved to some extent by two drill holes 257 and 400 feet in length, run at angles of 45 and 60 degrees respectively. This is the only deposit worked at present. No. 2, traced for over two miles in length and about 40 feet wide, consists of lean ore, the magnetite being interbanded with silicious material. The ore is too low in iron for blast furnace use, but it offers an interesting problem in magnetic concentration. Another outcrop of silicious ore occurs in the northwest corner of the property. No. 3 and No. 4 are bodies of high grade ore, not as yet proved to be as large as No. 1, but the ore is quite as good.

Actual mining operations have been confined to No. 1, the original Moose Mountain deposit. The surface of the ore body is 210 feet horizontally from, and 140 feet vertically above, the railroad track. The ore is won by overhand stoping from an open cut 65 feet high, trammed out and dumped on a large 30-degree chute, which delivers to a No. 8 Austin gyratory crusher, reducing the ore to 6-inch size. The ore then passes through a 48x12-inch trommel with quarter-inch perforations; the undersize going direct to the elevator pit, while the oversize is fed to a No. 5 Austin crusher, discharging into the elevator pit. The belt elevator conveys the ore in 14x30-inch buckets to the storage bin of 250 tons capacity, where it is loaded into railroad cars.

The power plant at present consists of a 16x42-inch Jenckes Corliss engine, steam being supplied by two 150-h.p. return tubular boilers. An air compressor will be installed shortly; at present the machine drills are operated by steam.

[9] W. G. Miller in Bur. Min. Rep., Vol. 16 (1907), p. 73.

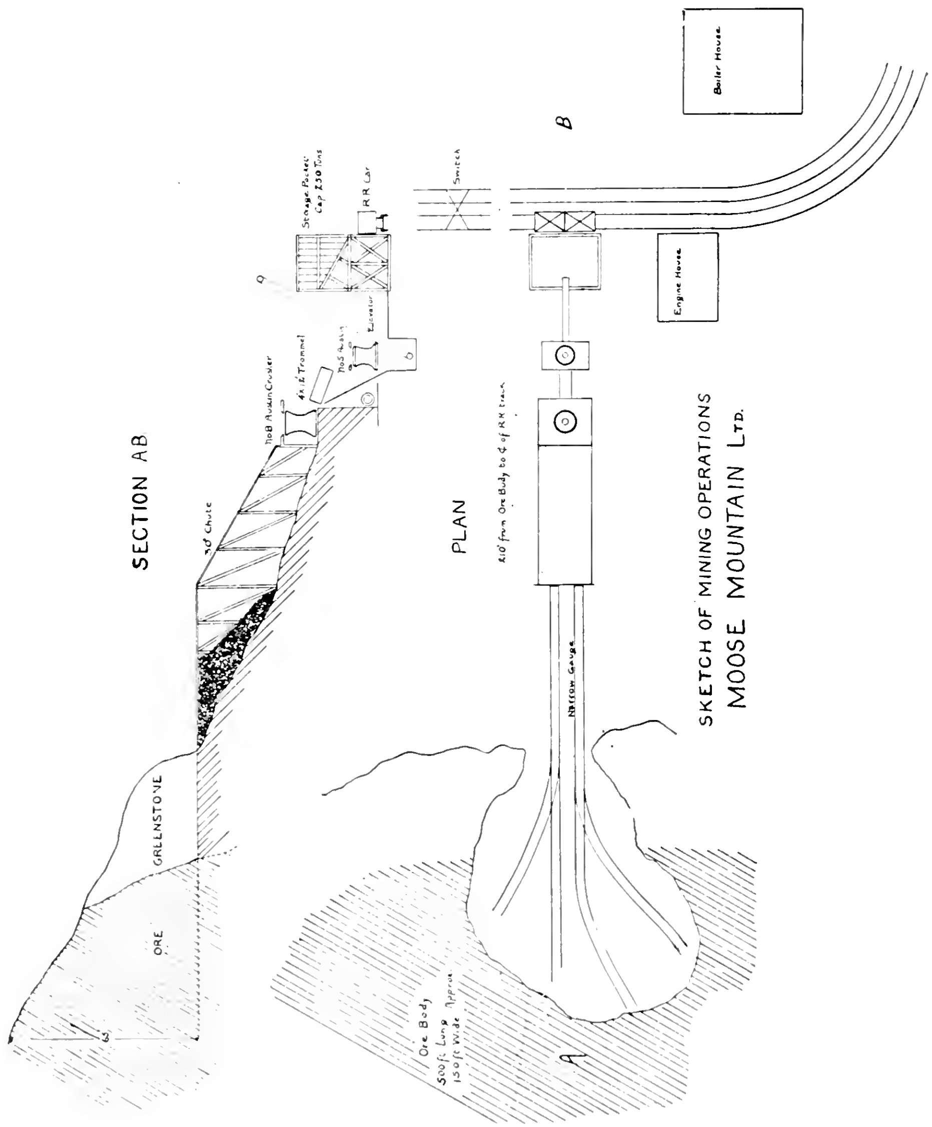
Moose Mountain. American Institute of Mining Engineers inspecting ore body at the open cut.



Moose Mountain mine. View from top of Moose Mountain.

It is expected that a considerable tonnage of this ore will be smelted in Ontario furnaces, but no doubt large shipments will be made to American ports, despite the import duty of 40 cents per ton. The guaranteed analysis of the ore is as follows:—

Fe	SiO_2	Al_2O_3	P	Mn	Ca O	Mg O	S	Moisture
55.50	13.29	1.21	0.10	.02	3.60	3.15	0.011	1.00



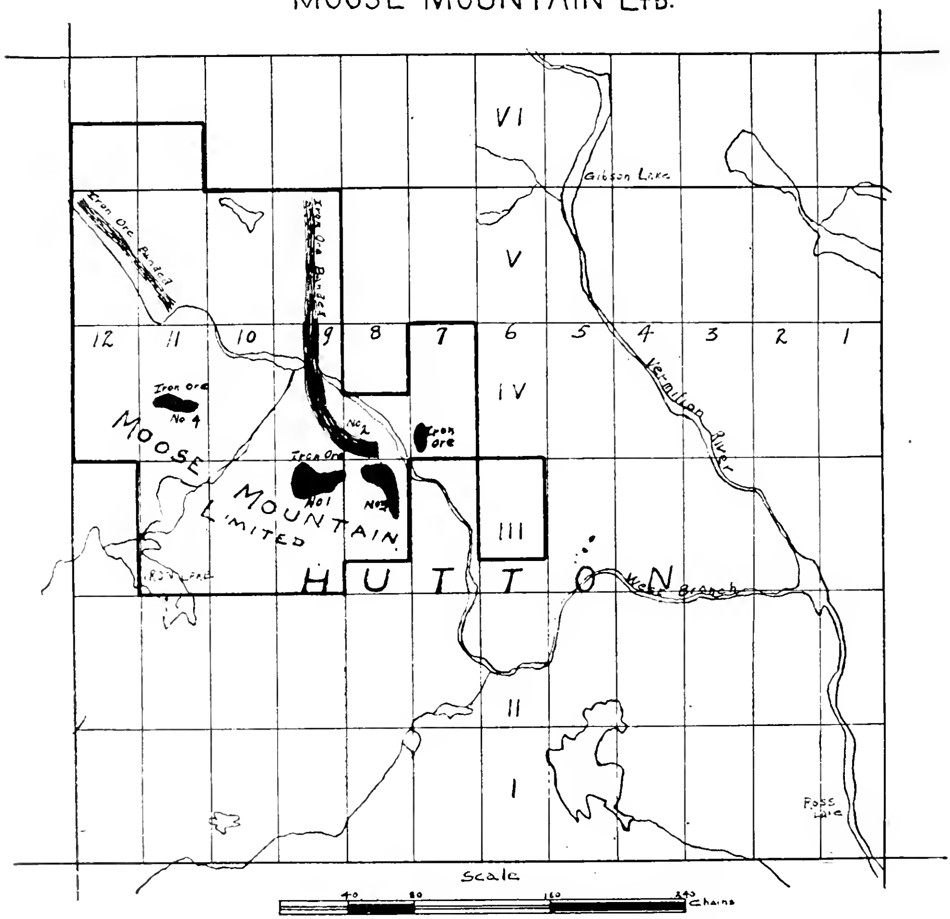
The ore will be shipped to Key Harbor on the Georgian Bay via the Canadian Northern railway. The Toronto to Sudbury portion of this line is completed now, and affords a rail haul of 80 miles only from the mine to the docks.

The docks at Key Harbor[10] are of original design, and unlike any on the great lakes for handling iron ore. The ore, arriving from the mines in drop bottom steel cars, is dumped from a trestle to a stock pile beneath. Under this stock pile, and in

[10] The Moose Mountain Ore Range, by N. L. Leach, Sudbury; Journal of the Canadian Mining Institute, Vol. xi

line with the centre line of the trestle, is a tunnel through which a 42-inch belt will convey the ore to a similar belt at the water's edge, which in turn conveys
the ore to the dock trestle, sixty feet above the water's level. It is then
the belt, weighed by an automatic device and dumped into pockets, from which it will be spouted into the hold of the vessels alongside the dock. It is expected that these belts will have a capacity of eight hundred tons of ore per hour.

TOWNSHIP of HUTTON
Showing Location of
MOOSE MOUNTAIN LTD.



The Key affords a splendid natural harbor, with 24 feet of water alongside the docks, more than enough to float the largest lake ore freighters. This shipping point is 500 miles nearer the iron ore receiving ports than the head of Lake Superior, which should prove a considerable factor in securing favorable lake freight rates.

Radnor Mine

The Radnor mine, owned by the Canada Iron Furnace Company, has been one of the most important producers of iron ore in Eastern Ontario.

The property consists of 100 acres in lots 16 and 17 concessions nine and ten in the township of Grattan, Renfrew county, and has been worked almost continuously since 1901.

The ore, which is a coarse grained magnetite, occurs in rather narrow beds varying in width from 4 to 10 feet. These beds have a general strike northwest and southeast, following each other almost in a semicircle, with an average dip of 34 degrees to the southwest, and lie in a micaceous gneiss, cut here and there by pegmatite dikes, penetrating the ore bodies in some cases.[11]

Mining is conducted in a series of 8 open cut pits, that follow the general semicircular trend of the ore, No. 8 pit being at the northwest end and No. 1 pit at the southeast extremity of the semicircle.

No. 2 pit is the largest, being 300 feet long with an average width of 35 feet, and is 40 feet deep. At its west end an incline shaft 8x18 feet has been sunk for 80 feet from the bottom of the pit, following the ore, which dips 35 degrees to the south. This shaft is equipped with a skiproad from the bottom to the top of the open cut, and shows the ore to be 10 feet wide at the top narrowing to six feet at the bottom.

Latterly all mining operations have been confined to pits 7 and 8, and extensive stripping of the overburden was carried out during the spring and summer of 1907 in preparation for opening the deposits on a larger scale.

Considerable diamond drilling has been done in the edge of the semicircle referred to above, and this drilling is said to have proved the deposit at depth.

The ore is raised by a 25-h.p. steam hoist, and also by horse whim operating a boom derrick, and is piled in bins, or along the hillside above the road, where it can be conveniently loaded by chutes into sleighs, thence hauled 3½ miles to Caldwell Station on the Grand Trunk railway. An average of 100 tons is mined per day.

Considerable difficulty is experienced in the winter months in keeping the open cuts free of snow, and in consequence frequent shut downs have resulted.

The run of mine is sorted by hand into two grades,[12] that running 48-50 per cent. in iron is shipped to the Company's furnaces at Radnor, Quebec, while the low grade, containing about 30 per cent. of iron is stocked at the mine. There is a considerable tonnage of this low grade ore which could be treated by magnetic concentration at a profit, provided mining costs could be kept low enough. An average analysis of the ore[13] shipped is shown below:—

Fe	SiO_2	S
47.50	19.5	0.25

Mineral Range Iron Mining Company

The Mineral Range Iron Mining Company was organized in 1902 by Mr. H. C. Farnum, to take over certain iron properties in the townships of Dungannon and Mayo, Hastings county. These deposits of magnetic ore had been prospected to some extent during the previous years by Mr. Farnum, and their exploitation and development are entirely due to that gentleman. The company control about 3,700 acres of mining lands, of which less than one-fifth are under development, the outlying ore bodies not as yet being reached by the railroad spur.

Near L'Amable station on the Central Ontario railway, a branch line called the Bessemer and Barry's Bay railway extends in an easterly direction for five and a half miles to the village of Bessemer in Mayo township, where the principal iron mines are located. Here are built the company's offices, stores, saw mill, comfortable houses for miners and members of the staff, railroad scales and chemical laboratory. A school is proposed to be built at an early date.

[11] Rep. Bur. Min., Vol. 11 (1902), p. 259. [12] Bur. Min. Rep., Vol. 14 (1905), p. 77. [13] Analysis supplied by Mr. G. D. Drummond, Canada Iron Furnace Co., Midland.

Mineral Range Iron Mining Company; railway siding..

Mineral Range Iron Mining Company; shaft and crusher house.

There are at present four ore bodies opened up at Bessemer, with a fifth called the Child's mine, situated two and a half miles to the east. Of the five, only two at Bessemer were being worked at the time of my visit, producing in the neighborhood of 135 tons per day of 10 hours.

All the ore bodies have a general strike N.E. and S.W., with a dip of 60 degrees to the south, and lie in diorite schists and greenstones mainly, with one or two intrusions of gneissoid granite. Crystalline limestone is found on the foot wall of all four ore bodies at Bessemer. The ore is generally fine grained magnetite, and the best quality will average 60 per cent. in iron, although considerable cobbing would have to be done on the general run of mine to keep it up to that standard. Phosphorus is well within the bessemer limit, and sulphur, which occurs as iron pyrites, is found in small stringers easily separated by hand sorting.

At No. 3 open cut the pit 36 feet deep and 80 feet square is all in ore. This ore body is approximately 300 feet wide, and has been opened for 800 feet in length. Unfortunately, the ore is not all high grade and must be cobbed freely. About 35 tons of high grade and 50 tons of low grade ore are mined per day from this pit. A diamond drill hole has been put down, and at 160 feet in depth the ore showed no change. The ore is hoisted by a 70-foot boom derrick, operated by a 5-h.p. double drum hoist, steam being supplied by two boilers of 20 and 25-h.p. respectively. Drilling is done by machine drills run by steam.

No. 4 mine is an open cut 55 feet deep and 500 feet long. This pit is producing 100 tons daily of shipping ore. At the west end of the open cut, a three compartment 8 x 14 foot shaft is being put down, following the dip of the ore, and will be of considerable assistance in increasing the output. The ore is first sorted in the pit, and then hoisted by a 2-ton skip and dumped direct into a No. 6 Gates crusher, that delivers to a storage bin of 40 tons capacity. From this bin the ore is loaded into ralroad cars alongside the crusher house. Ore from No. 3 pit is trammed to No. 4 and dumped into a 60-ton bin, situated immediately over the collar of the incline shaft. From this bin it is loaded into the skip and hoisted to the crusher.

The Gates crusher is run by a 50-h.p. engine, situated on the ground floor of the crusher house. Hoisting is accomplished by a 5-h.p. single drum hoist, steam being supplied by two 80-h.p. boilers of the locomotive type, one being used at a time. The machine drills are operated by steam as at No. 3.

The ore body at No. 4 is 55 feet wide, both walls being clearly defined, and can be traced for 1,800 feet in length on the hanging wall side, and for 40 feet towards the foot wall. The ore is high grade, very little sorting being necessary. The remaining 15 feet of ore is of second quality and high in sulphur. The pyrites however is not disseminated throughout the ore, but is found in fairly large masses, and along the contact of the ore and country rock, hence it appears to offer an easy problem for magnetic concentration.

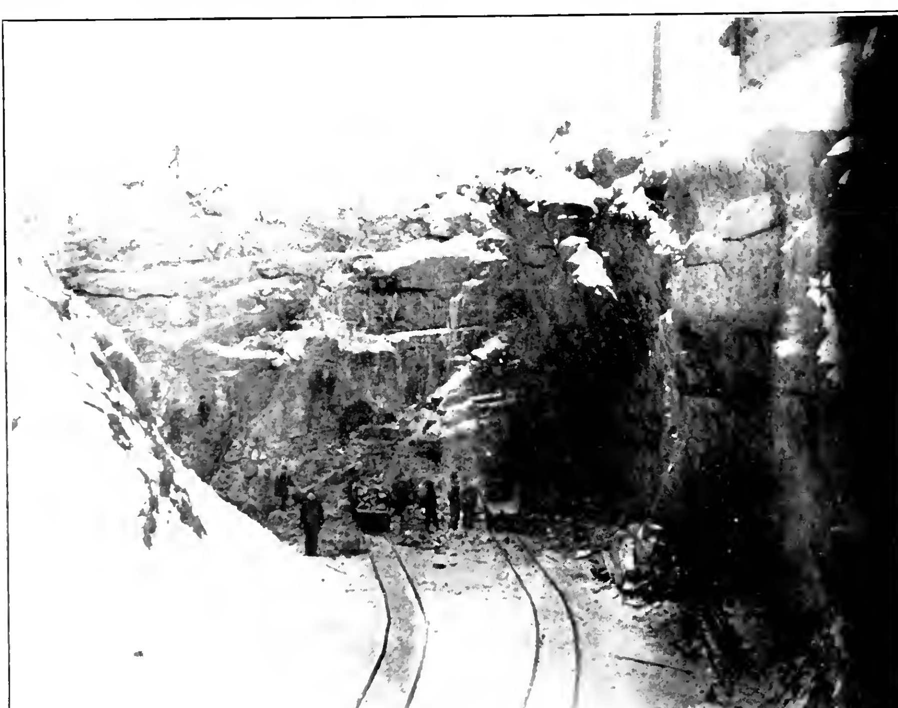
At the Child's mine, there is an immense body of low grade ore, averaging 40 per cent. in metallic iron; phosphorus and sulphur are both within bessemer limits, the gangue consisting of intermixed hornblende and calcite, with a varying proportion of silica. This large ore body, together with the amount of low grade magnetite from the deposits at Bessemer, could easily supply a concentrating mill of 1,000 tons daily capacity for many years. Cheap electric power could be developed at Egan's chutes on the York branch of the Madawaska river, 4½ miles from Bessemer. The chutes have a total fall of 22 feet.

At the present time the mines are shipping to The Canada Iron Furnace Company, at Midland, Ontario, and Radnor, Quebec, also to the Deseronto Iron Company of Deseronto. An average analysis[14] of the shipping ore is as follows:—

Fe.	SiO_2	Al_2O_3	P	Mn	CoO	MgO	S
54.29	9.84	2.02	0.019	0.38	6.86	1.35	.062

[14] Analysis supplied by Mr. G. D. Drummond, Canada Iron Furnace Co., Midland, Ont.

Childs mine, Mineral Range Iron Mining Company.



Mineral Range Iron Mining Company. Open cut at No. 4 mine.

Wilbur Mine

This property is one of the more promising mines in the eastern part of the Province. Located in the township of Lavant, Renfrew county, about 60 miles north of Kingston on the Kingston and Pembroke railway, the Wilbur, in company with other mines of the district, has had in the past an alternating series of active and dormant periods.

At the present time the mine is operated under lease from the owners by the Wilbur Iron Ore Company, and the product is for the most part being shipped to the Algoma Steel Company of Sault Ste. Marie.

The ore is magnetic, more or less coarsely crystalline, and seamed with chlorite and calcite. The percentage of iron in the run of mine will average 50, but this is brought up to 55 by sorting. Sulphur and phosphorus are both low, and the ore will rank as a bessemer.

The magnetite is found as a series of detached ore bodies[15] at the contact of crystalline limestone and gneissoid granite, limestone being invariably found on the foot wall. The strike of the contact at the principal workings is approximately a little east of north, and the ore body dips at an angle of 27 degrees to the east, passing underneath the gneiss, the formation flattening out in depth in some places as low as 8 or 10 degrees.

Diamond drilling has been done to a considerable extent, some 27 holes having been put down at various times, varying in depth from 60 to 350 feet. Unfortunately, records of these holes have not been kept, but it is stated that the ore pierced by the different drillings was from 3 to 28 feet in thickness. There are eight workings altogether, the most important being known as No. 3A, 3B, and No. 4. The work at 3A and 3B consists of two incline shafts sunk from the bottom of a shallow open cut. The old shaft 3A is inclined at an angle of 30 degrees and is 150 feet deep. The collar of shaft 3B is about 30 feet north of 3A, and has a starting incline if 27 degrees, but flattens out considerably at depth. This shaft has attained to a depth of 350 feet and is the only one being worked at present.

Workings 3A and 3B are connected by drifting at two different points, and levels have been started in a northerly direction at three points in shaft 3B, the ore being extracted by both overhand and underhand stoping. The output of the mine at present is 150 tons per day, but this will be increased before long to 200 tons daily.

The ore is hoisted by skip, and dumps direct to a 10 x 20-inch Blake crusher, from which it is carried by a bucket elevator to a sorting belt, running at right angles to the elevator, and situated on top of the shipping pockets, which are built immediately over the railroad spur. There are 13 of these pockets, one or two being used for waste, the remainder for ore. Provision is made whereby the ore can be loaded from the pockets through bottom gates into gondola cars, or else chuted into box cars through side gates.

The hoist and crusher house contains a double cylinder single drum hoist operating the skip, the Blake crusher and a 12 x 16-inch single engine for driving the crusher, elevator and sorting belt. In the power house, which is a separate building, are two boilers of 180 combined horsepower, a 3-drill Barber air compressor, and a small electric light plant, supplying the mine workings both under and above ground, also the office and store. Railroad scales have been built and all ore is weighed before being shipped.

An analysis of the shipping ore is as follows:

Fe.	Insoluble.	S.	P.
55.49	3.45	0.04	0.022

[15] Iron Ore Deposits along the Kingston & Pembroke Railway, by E. P. Ingall; Geo. Sur. Can., Annual Report, Vol. XII.

III.—The Magnetic Concentration of Iron Ores

It has been pointed out in preceding pages that there are numerous localities in Ontario where magnetic iron ore occurs in considerable quantities, and if it were not for certain harmful substances found associatel with these ores, they would have considerable commercial value on account of their proximity to the consuming markets. Sulphur and phosphorus are the most common and hurtful of the obnoxious elements, and by their presence or absence in appreciable amounts, determine whether an ore is fit for the manufacture of certain grades of iron and steel. Fortunately, it happens that in the great majority of cases, these pernicious substances exist as separate chemical compounds that are not so susceptible to magnetic influence as the pure magnetite itself, and by taking advantage of this circumstnce these compounds can be eliminated, and the ore made suitable for smelting.

This fact has led to the expenditure of much money and ingenuity in attempts to perfect a magnetic separating machine that will accomplish the desired result in an effective and economical manner. The patent office files of the United States and some of the European countries, notably Sweden, are replete with hundreds of records covering the many attempts to devise such machines. Most of the earlier types of magnetic separators invented were weak and could only be applied to highly magnetic material; in others the arrangement of the magnetic field was such that they yielded but indifferent results, and the mechanical construction being complicated, the cost of operation and repairs was excessive.

Of late years the question of design of these machines has been better understood, and as the necessity for magnetic concentration became more and more apparent their construction fell naturally into the hands of competent electricians, with the result that we have at the present time several different types of machines, adapted to different requirements, and giving satisfactory results on a commercial scale.

The constantly increasing drain on the iron ore supply of the world, and particularly of this continent, is a fact well understood by all iron men. The best grade of ores is becoming scarcer with prices correspondingly higher year by year. A short time ago the markets were glutted with rich ores at moderate prices, and it would then doubtless have proved unprofitable to attempt the mining and concentration of low grade deposits. However, the tremendous rate of consumption of iron ore during the past decade has altered this state of affairs considerably, and at the present time the winning of the poorer ores is regarded not only as a profitable investment, but as a necessary auxiliary to the main ore supply.

The following table[16] shows the range of prices for Lake Superior ores during the three years beginning with 1906, and also the lowering which is going on in the standard for metallic contents:

Bessemer Ores.	Old Range.			Mesabi.		
	1906	1907	1908	1906	1907	1908
Iron % natural	56.70	55.00	....	56.7	55.00	....
Moisture	10.00	10.00	....	10.00	10.00	....
Iron % dried at 212°	63.00	61.12	....	63.00	61.12	....
Phos. %	0.045	0.045	....	0.045	0.045	....
Base Price $	4.25	5.00	5.00	4.00	4.75	4.75

Non-Bessemer.	Old Range.			Mesabi.		
	1906	1907	1908	1906	1907	1908
Iron % natural	52.08	51.5	....	52.8	51.5	....
Moisture	12.00	12.00	....	12.00	12.00	....
Iron % dried at 212°	60.00	58.52	....	60.00	58.52	....
Base Price $	3.70	4.20	4.20	3.50	4.00	4.00

It will be noted in the above table that the iron content for standard ores in the natural was 56.7 per cent. in 1906 and reduced to 55 per cent. in 1907, with an increase in price of 75 cents per ton. No doubt the standard will suffer future reductions as the high grade ores become scarcer. This point is appreciated keenly by furnacemen,

[16] The Mineral Industry, 1906, and Iron Age, February 13th, 1908.

for an increase in the average percentage of iron contained in the ore charged to the furnace means increased output, lower fuel consumption, less flux required, and consequently a more evenly running furnace at lower costs per ton of iron produced.

Concentrates in the Furnace

Magnetic concentrates when carefully prepared will materially assist in proper furnace control. Not only are they low in sulphur, phosphorus, and slag-forming ingredients, but the percentage of iron will be nearly uniform, varying only a fraction of one per cent. from time to time. This is an item of great importance, for uniformity in the grade of raw materials is much desired and appreciated by all furnacemen.

There is, however, one serious drawback to the successful use of some concentrates, and that is the fineness of the material. If it is found necessary to grind the crude ore to a fine state of subdivision in order to make a clean separation, the resulting product will be unfit for direct use in the furnace, because a large portion of these fines when charged will be lifted up and carried out of the furnace by the rush of the ascending gas currents, filling up the gas mains, and accumulating under the boilers and in the hot blast stoves. The portion which remains in the furnace will also contribute its share of trouble by non-uniformity of descent with the coke and limestone, giving rise to irregularities in the smelting operations. Concentrates of this character require a preliminary treatment before they can be used in the blast furnace, such treatment consisting of a process of briquetting or nodulizing, forming small bricks or nodular masses of the fine material.

Just what degree of fineness makes the use of this concentrated ore prohibitive, without any preliminary treatment, depends on the percentage of pulverized material in the concentrates. In the use of Mesabi ores, it is stated[17] that where less than 12 per cent. passes through an 80-mesh sieve, such ores are considered as having good physical structure, from 12 to 18 per cent. a fair structure, and more than 18 per cent. a poor structure, but it is also pointed out that ores other than the Mesabi have been successfully smelted that contained as much as 20 per cent. of material fine enough to pass a 100-mesh sieve. Hence it is evident that a fair comparison with fine ores of the Mesabi type cannot be made. However, it may be taken as an axiom, that concentrates containing more than 20 per cent. of fine material that will pass an 80-mesh sieve, will give considerable trouble and should undergo some process of agglutinizing before they can be smelted with profit.

As a factor in the manufacture of steel in the open hearth, the value of magnetic concentrates has been proved beyond a doubt, and is freely conceded by practical steel makers. The process of electric manufacture of iron and steel, although in its infancy at present, will doubtless prove a large user of these concentrates, and as there is a promising future in Ontario for the production of iron and steel by electrictiy, the market for concentrated iron ores will undoubtedly expand.

Magnetic Attraction the Basis of Concentration

Most people are familiar with the fact that a magnet will attract iron, but few are aware that a magnet can be designed and built strong enough to attract almost any material. The cost of building and operating such a magnet for the commercial concentration of many materials is usually prohibitive. But nevertheless the fact remains, and it may be stated as a curious circumstance that pieces of wood, apples and other things generally considered non-magnetic, have been moved magnetically through several inches.[18]

[17] The Use of High Percentage of Mesabi Iron Ores in Coke Blast Furnace Practice, by W. A. Barrows. Trans Am. Inst. M.E. Vol. XXXV., page 140.

[18] Magnetic Separation, by F. S. Snyder, Journal Can. Min. Inst., Vol. VII., page 270

In this report the problem of magnetic attraction and consequent separation of the mineral magnetite from its associated gangue or rock matter will be considered, and a description of the salient features only of the process will be discussed. For more extended literature on the subject the reader may consult the list of references given at the end of the report.

All of the iron-bearing minerals are more or less susceptible to magnetic attraction. The relative permeability (magnetic conductivity) of the different minerals has been worked out by Walter Crane.[19] A partial list is as follows:—

Mineral.	Permeability.
Iron	2.1617
Magnetite	1.4669
Franklinite	1.4112
Ilmenite	1.2871
Pyrrhotite	1.0782
Hematite	1.0242
Siderite	1.0234
Limonite	1.0099
Pyrite	1.0064
Quartz	1.0055
Apatite	1.0026

It is evident that if a difference in permeability affords a means of separating the minerals, the wider this difference is, the easier will be the operation. Particles of pyrite or apatite can be easily separated from particles of magnetite, particles of ilmenite and pyrrhotite not so easily. However, this point is thoroughly understood by designers, and has been so well taken advantage of in certain type of machines, that a very small difference in the permeability of two different minerals will afford the means of separating them.

The Problem of Concentration

Concentration or separation of any ore from its gangue means the selection of the valuable mineral contained therein from the worthless rock matter. Obviously, the simplest method of effecting the selection is by hand sorting or cobbing. With some of the soft ores mixed with clay or calcareous matter, concentration consists of a system of crushing and treatment in pulsating water jigs, or by means of the log washer used in the Southern States, which is described as a tilted cylinder rotating on its longer axis, with side paddles forcing the ore upwards against a descending stream of water which washes away the clay and fine material through screens at the lower end, while the clean ore passes to ore cars at the upper end.[20] Hand sorting is slow and costly, and when the particles of valuable mineral and gangue are small and intimately mixed, an effective separation is difficult. Hydraulic classification and jigging methods depend upon the difference in specific gravity of the constituent minerals; and when magnetite is associated with pyrite, both of about the same weight and hardness, hydraulic separation does not afford commercial results. With the electro-magnet, the difference in permeability between the magnetite and pyrite affords a commercial method of separation, and even the mineral pyrrhotite may be eliminated by a magnetic separating machine of suitable design.

In all cases, efficient magnetic separation will depend upon the various mineral constituents of the crude ore being crushed or broken fine enough, so that individual grains are free to be attracted or rejected according to their permeability. Just here is the crucial point. If the ore must be pulverized very fine say to 50-mesh (0.010 inch) to obtain an efficient recovery of the magnetite particles, the cost of crushing will be much more than if such preliminary treatment consisted in breaking the ore to 5-mesh (0.10 inch). For example, a cube that will pass through a 0.1 inch hole must be reduced to 1/1000 of its original mass in order to pass a 0.01 inch hole, the difference in the cost

[19] Trans. Am. Inst. M.E., Vol. XXXI., page 444.

[20] Magnetic Concentration of Iron Ores, by J. Walter Wells, Bur. Min. Rep., Vol. XII. (1903), page 323.

of producing these two grades being a consideration of some importance. Then again the fine grained product, as has been pointed out, is not so desirable from the furnaceman's point of view.

As a general rule it may be stated that the preliminary crushing should be carried only far enough to break away the average sized particles of magnetite from the gangue, and at this point a three-part separation should begin. The products of this process are pure magnetite requiring no further treatment, tailings that can be disposed of as waste, and middlings consisting of part magnetite and part gangue that should be re-crushed for a secondary concentration, the products of this secondary concentration being added to the heads and tails of the first separation. If the tailings from the secondary concentration still contain an appreciable quantity of magnetite, it may be found profitable to re-grind them and make a third separation, the economical point to which separation may be carried depending upon the percentage of iron in the crude ore, the cost of crushing, and the value of the concentrates produced.

There are exceptions to the foregoing in cases where the crude ore consists of magnetite and gangue matter in so fine a state of crystallization and so intimately mixed that the whole mass must be reduced by crushing and grinding to 80 or 100-mesh in order to free the particles of magnetite. In consequence of this excessive pulverization, the ordinary methods of dry separation do not afford efficient results, and such finely ground ores must be treated by a special wet process.

Factors of the Problem

To gain an idea of the efficiency of any proposed method of ore separation, the investigator should have representative samples of the crude ore, the concentrates and the tailings, obtained under conditions that are approximately similar to those in actual commercial practice. The efficiency and value of any such system may then be determined by the application of the following simple equations,[21] together with due consideration of the physical character of the crude ore and concentrates, the capacity and durability of the concentrating machines, the requisite method of preparing the crude ore for separation, and the power and labor required for the operation of the process.

Let a = Per cent. of magnetite in the concentrate.
b = " " " tailings.
c = " " " crude ore.
d = Units of crude ore required to make one unit of concentrate.
e = Units of tailings for one unit of concentrate.
f = Per cent. of magnetite in the crude ore which is saved in the concentrate.
g = Per cent. of magnetite in the crude ore which is lost in the tailings.

Then (1) $\dfrac{a-b}{c-b}=d.$ (3) $\dfrac{100\ a}{cd}=f.$

(2) $\dfrac{cd-a}{e}=b.$ (4) $\dfrac{100\ be}{cd}=g.$

(Note....Per cent. of iron divided by 0.7242=per cent. of magnetite. Per cent. of magnetito multiplied by 0.7242=per cent. of iron.)

Example. A certain ore contains 50 per cent. of magnetite and 50 per cent. of gangue. In separating this ore, the per cent. of magnetite in the concentrates is 90 (65.178 per cent. iron) with 4.5 per cent. of magnetite (3.26 per cent. iron) left

[21] See "The Magnetic Separation of Iron Ores," by Clinton M. Ball. Trans. Am. Inst. M.E., Vol. XXV., page 533

in the tailings. According to equation (1), $\frac{90-4.5}{50-4.5}=1.879$ units of crude ore are required to make one unit of concentrate, and by equation (3) we have $\frac{90 \times 100}{1.879 \times 50}$ $=95.79$ per cent. of the magnetite in the crude saved in the concentrate, with 4.21 per cent. lost in the tailings, hence the efficiency of the operation is very nearly 96 per cent.

Equation (4) is used to check equation (3) and equation (2) to check the accuracy of mine and mill reports. The following analysis may make this more clear:—

10 units of crude ore, half magnetite and half gangue. =	5.322 units of concentrates (53.22 p.c.) =	Magnetite =	90 p.c. =	4.79 units	
		Gangue =	10 p.c. =	0.532 "	
					5.322 units
	4.678 units of tailings (46.78 p.c.) =	Magnetite =	4.5 p.c. =	0.21	
		Gangue =	95.5 p.c. =	4.468	
					4.678
			Total		10.00

By this analysis it is seen that 4.79 units of magnetite in the concentrates divided by 5 original units of magnetite in the crude ore=95.8 per cent. of the magnetite in crude ore saved in concentration, and 0.21 units of magnetite in the tailings divided by 5 original units of magnetite in the crude ore=4.2 per cent. of the magnetite which is lost in the tailings. Also the ten original units of crude ore divided by 5.322 units of concentrates=1.879 crude units per unit of concentrate.

In the above it is assumed that the crushed ore was ready for complete separation at once, the per cent. of magnetite in the tailings being so low that it is doubtful whether re-crushing and re-separation would prove profitable.

Three-Part Separation

Now, suppose that the crude ore is of such a character physically that after preliminary crushing it is found best to make a three-part separation, nine-tenths of the original ore making concentrates and tailings, and one-tenth a middling product that would in quality correspond very closely to the original crude ore. The preceding analysis and equation shows that 1.879 units of this crude ore if properly treated would make one unit of concentrate consisting of 90 per cent. of magnetite and 10 per cent. of gangue, and 0.879 unit of tailings consisting of 4.5 per cent. of magnetite and 95.5 per cent. of gangue, the concentrates constituting 53.22 per cent. and the tailings 46.78 per cent. of the crude ore thus treated. A consideration of the following analysis will show the importance of understanding the distribution of the products derived from ten units of crude ore by this three-part system.

				P.C.	Units	Units
10 units crude ore	9 units =	Concentrate 53.22 p.c. =	Magnetite =	90 =	4.311	
			Gangue =	10 =	.479	
						4.79
		Tailings 46.78 p.c. =	Magnetite =	4.5 =	0.19	
			Gangue =	95.5 =	4.02	
						4.21
	1 unit of middlings same as crude re-crushed and re-separated =	Concentrate 53.22 p.c. =	Magnetite =	90 =	0.47898	
			Gangue =	10 =	0.05322	
						0.5322
		Tailings 46.78 p.c. =	Magnetite =	4.5 =	0.021051	
			Gangue =	95.5 =	0 446749	
						0.4678
			Total			10.00

The sum of the concentrate units being 5.322, and of the tailings 4.6778, making a total of 10.

If instead of re-crushing and re-separating the middlings they are added to the concentrate the result would be:—

			P.C.		Units	Units
10 units of crude ore	Concentrate 57.9 p.c.	Magnetite	83.09	=	4.811	
		Gangue	16.91	=	0.979	
						5.79
	Tailings 42.1 p.c.	Magnetite	4.5	=	0.19	
		Gangue	95.5	=	4.02	
						4.21
			Total..........			10.00

Thus increasing the percentage of concentrate obtained from the crude ore, from 53.22 to 57.9 per cent., but at the same time increasing the gangue in the concentrate from 10 per cent. to nearly 17 per cent., the percentage of iron in the concentrate being lowered thereby from 65.178 to 60.17, the percentage of waste remaining the same. If on the other hand to avoid this depreciation in quality of the concentrates, the middlings are thrown away with the tailings. the result would be:—

				P.C.		Units	Unit
10 units of crude ore =	Concentrate 47.9 p c. =	Magnetite	=	90	=	4.311	
		Gangue	=	10	=	.479	
							4.79
	Tailings 52.1 p.c. =	Magnetite	=	13.24	=	0.69	
		Gangue	=	18.76	=	4.52	
							5.21
				Total.............			10.00

Hence it is clear that 4.311 units of magnetite in the concentrate divided by 5 original magnetite units in the crude ore=86.2 per cent. of the magnetite in the crude saved in concentration instead of 90, and 0.69 divided by 5=13.8 per cent. of magnetite lost in the tailings instead of 4.2. as in the three-part separation; also that 10 divided by 4.79 concentrate units≐2.087 crude units required to make 1 concentrate unit, instead of 1.879 required as in the three-part separation, a difference of 0.208 units.

It is evident that if the ore will respond to this system of separation, a fine crushing of the whole mass in one operation would be an unreasonable expense, and should be avoided. It is also apparent that as much as possible of the magnetite in the crude ore should be saved, because if the ore is costing 75 cents a ton delivered at the mill, a difference of 0.208 tons in the amount of crude required to make one ton of concentrate is equivalent to 15.6 cents a ton, for or against, the initial value of the crude ore. The difference between concentrates containing 60 and 65 per cent. of iron is also of great importance to the consumer, for it means an increased output of iron from the furnace, with a corresponding reduction in the final cost per ton of pig iron.

The following table[22] prepared by Mr. John Birkinbine may be of interest showing the theoretical quantity of ore of any percentage of iron betwen 20 and 55, which is necessary to produce one ton of 65 per cent. concentrate with a loss of 10 per cent. of iron in the tailings. Allowance is also made for a 5 per cent. loss in dust, moisture, and sulphur.

[22] Trans. Am. Inst. M.E. Vol. XX, p. 598.

Table showing Theoretical Tonnage Ratio of Crude Ore in Concentrate

Iron in Crude Ore	Crude Ore required to produce one ton of 65 per cent. Concentrates, and allowing 10 per cent. loss in the tailings.	
	Without allowance for dust, etc.	Allowing 5 per cent. for dust, etc.
Per cent.	Tons	Tons.
20	5.500	5.775
21	5.500	5.250
22	4.583	4.812
23	4.231	4.443
24	3.929	4.425
25	3.667	3.850
26	3.438	3.610
27	3.235	3.397
28	3.056	3.209
29	2.895	3.040
30	2.750	2.888
31	2.619	2.750
32	2.500	2.625
33	2.391	2.511
34	2.292	2.407
35	2.200	2.310
36	2.115	2.221
37	2.037	2.139
38	1.964	2.062
39	1.897	1.992
40	1.833	1.925
41	1.774	1.863
42	1.719	1.805
43	1.667	1.750
44	1·618	1:669
45	1.571	1.650
46	1.528	1.604
47	1.428	1.560
48	1.447	1.519
49	1.410	1.481
50	1.375	1.444
51	1.341	1.408
52	1.310	1.376
53	1.279	1.342
54	1.250	1.313
55	1.222	1.283

Types of Magnetic Separators

A complete description of all the various types of magnetic separators is alike beyond the scope of this report and the knowledge of the writer. Accordingly, only a few of the various machines will be described and only those which, so far as known, are giving commercial results.

Generally speaking, there are two distinct methods of separating iron ore in use at the present time:

(1) Dry separation, which requires the crude ore to be thoroughly dried before it is separated, and is applicable only to those ores that do not require fine grinding. (2) Wet separation, which necessitates the concentrates being dried before they are briquetted or nodulized, and is specially applicable to those ores that require fine grinding in order to separate the constituent minerals.

The various types of separators have been classified by J. Walter Wells[23] as follows, and for the present purpose this classification will suffice:—

(1) Those in which the ore is fed on conveying belts either traversing magnets or traversed by them. Examples are the Conkling, Wetherill, Ball & Norton belt machine, Chase, Hoffman, Kessler, Knowles and similar machines.

(2) Those in which the ore is fed upon a revolving drum, within which is arranged a system of magnets. Examples are the Ball & Norton, Gröndal, Heberli, Wenstrom, Buchanan, Sautter, Siemens, Payne and others.

23 Bur. Min. Rep. 1903, Vol. XII., p. 325.

(3) Those in which the ore falls vertically past magnets. Examples are:—Heberli, Gröndal-Delvik, Rowand, International (a new machine), and the Edison system.

Belt Machines

The Conkling separator, although not in use at the present time, illustrates the earlier type of belt machine, and may be briefly described as an endless feed belt above which are suspended three electro magnets. Between the magnets and the feed belt smaller belts are run at right angles, carrying off the concentrates as

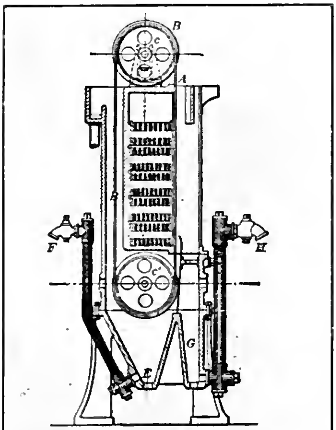


FIG. 470b.—VERTICAL CROSS SECTION.

The Grondal Delvik magnetic separator.

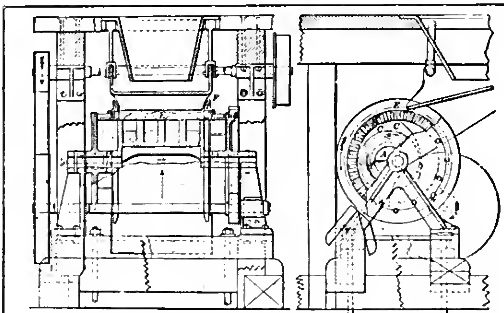
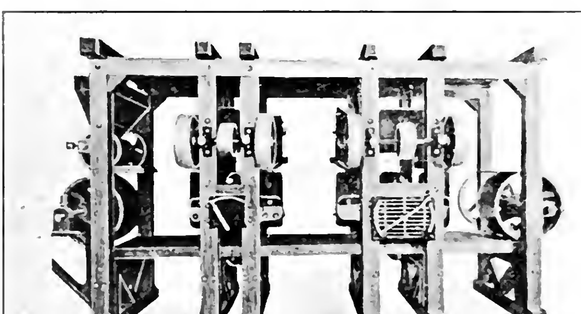


FIG. 463a.—LONGITUDINAL SECTION OF WENSTROM MAGNETIC SEPARATOR. FIG. 463b.—CROSS SECTION.

The Wenstrom magnetic separator.

they are lifted by the magnets from the feed belt, the tailings being conveyed over the end of the main belt. This machine has not been very successful, although in an improved form it has been used to some extent at the Tilly Foster mine in New York State.



Wetherill magnetic separator, type E,

The Wetherill belt machine is a type that has been in more or less successful operation for some years, and is made in different forms to suit different requirements. Its construction is shown in the accompanying diagram. The ore is fed upon an endless belt that passes between the pole pieces of electro-magnets. Cross

belts carry the magnetic heads to one side, and the tailings pass undisturbed to the discharge end of the feed belt. The arrangement of passing the feed between the poles of the magnets is a distinct advance upon the Conkling type, because the feed belt cuts the lines of force at one point only. In the Conkling, both poles being on the same side of the feed belt, the lines of force are looped and are cut twice, consequently the magnetic particles are given a swirling motion, and much dust is carried along mechanically with the heads. This is avoided in the Wetherill, and as the pole pieces are hatchet shaped, the lines of force are concentrated where most needed, thus making the machine very effective on weakly magnetic material. The Wetherill separator is used in Mineville, New York State, to separate hornblende from apatite. It has also found some use in South Africa separating garnets from diamonds, and at the Franklin Furnace, New Jersey, in the separation of zinc ores. Another purpose for which the machine has been found efficient is the cleaning of monazite sands. The accompanying photograph of a full sized Wetherill separator shows it to be rather complicated. The construction is such that repairs are heavy if any considerable tonnage is handled.

The Ball & Norton belt machine has been developed at the plant of the Witherbee Sherman Company, New York State, and as regards simplicity of design and efficiency of operation on the material for which it is intended, is giving every satisfaction. The magnets are arranged in a series of alternating polarity which causes each particle of magnetite to turn over and over as it passes through the field, producing a jigging motion, and allowing the entrained particles of gangue to fall away. The ore is fed to a wide belt carrying it into the magnetic field, where the particles of magnetite jump towards the magnets, and are held in suspension by the take-off belt as it passes through the field. The concentrates are delivered by the retaining force of the magnets and the forward motion of the take-off belt. The tailings are delivered partly from the feed belt and partly by the jigging process that takes place underneath the magnets. The take-off belt is run from three to four times as fast as the feed belt, but this ratio must be determined experimentally for any given ore. The magnets may be of any number desired, and by dividing them into two or more sections, each controlled by a rheostat, any degree of concentration may be obtained, as for instance a three-part separation.

Drum Machines

One of the best types of magnetic separators is the Ball and Norton double drum machine. This separator has been in successful operation for the past 15 years, with gratifying results. According to Mr. Ball,[24] the essential features are as follows: —

(1) A stationary range of magnetic poles of alternating opposite polarity in the direction of the ore travel, underneath which the drums, enclosing the two groups into which the range of poles is divided, may be rotated and may serve as carriers of the granulated ore, the iron particles being held on the underside thereof by magnetic attraction.

(2) Means for applying a strong counter current of air to the moving mass of ore while it is suspended upon the under side of the rapidly-running drums, and being driven along through the machine.

(13) Provisions for classifying the ore under treatment into three grades, this being effected by a differential speed of rotation of the two drums, assisted by relative adjustment of the strength of magnetism in the two groups of alternating magnets.

The drums may be made of any tough non-magnetic material, such as brass or fibre, the cylindrical portion of the casing being covered with thin rubber to protect it from the abrasive action of the sharp particles of ore. If the drum is made of metal, the magnetic field sets up eddy currents travelling across the cylinder at

[24] Trans. Am. Inst. M. E., Vol. XXV., p. 533.

right angles to the direction of rotation, hence consuming a certain amount of power. This is avoided in drums of non-metallic construction, but the metallic drums are more lasting and although requiring more power to drive are generally made of brass.

The electro-magnets are stationary and are mounted on a spider that can be moved through any desired arc of circle by means of an outside arm. In the double drum machine there are usually 15 or 16 magnets in the first. and 10 to 12 in the second drum, each set being controlled by a separate rheostat, the strength of the magnetic field being adjusted as required by circumstances. In practice the first drum to which the crude ore is fed is rotated at a speed of 40 to 80 R.P.M., the magnets being excited by a current of about 10 to 16 amperes. The second

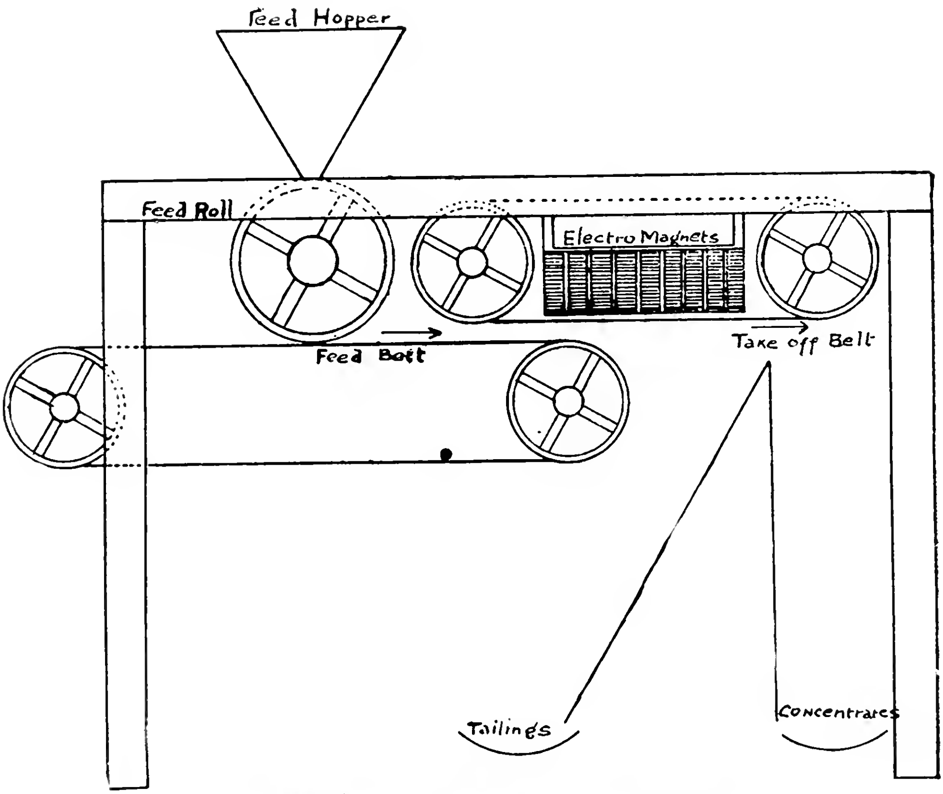


Diagram sketch of Ball and Norton belt separator.

drum is run faster, anywhere from 100 to 150 R.P.M., and the magnets are supplied with less current, approximately from 4 to 8 amperes.

Ore is fed through the hopper on top of the first drum, and the slow speed of this drum with its strong magnetic field, combines to pick up nearly all the magnetic particles, the non-magnetic tailings dropping to the receiving hopper below. The mass of magnetite is carried to the gap between the two drums where it is thrown off against the second drum, and as this second drum is running much faster than the first, with a weaker magnetic field, only the purest magnetite is held, the middlings consisting of part magnetite and part gangue dropping to a second receiving hopper. The pure concentrate is carried forward and thrown off centrifugally as it passes outside of the magnetic field. The middlings may be re-crushed and re-separated in a second operation.

The arrangement of alternate polarity of the magnets causes a tumbling or jigging motion in the mass of ore as it passes over the face of the drums, and allows the non-magnetic particles to weep out. Also the adjustments obtainable, in speed and in strength of magnetic field for each drum, control the power of selection to a nicety.

Very often the machine is built with a single drum, the products obtained being concentrates, and tailings that are re-crushed and re-separated. A single drum machine is giving satisfactory results used as a cobber, at the Witherbee Sherman mines, New York State. The double drum separators are used at the Chateaugay, Mineville, Arnold Hill and Benson mines in New York State, at the Hibernia mines in New Jersey, at Svarto in Sweden, and elsewhere.

The Grondal Separators

Mr. Gustaf Gröndal of Sweden is the inventor of five different separating machines that bear his name. His first attempt was patented in 1897, and is known as the Gröndal type No. 1. A few years afterwards he brought out a second machine, and a third followed shortly afterwards. The Gröndal type 3 separator is in use at the Lebanon plant of the Pennsylvania Steel Company, but is being supplanted by the

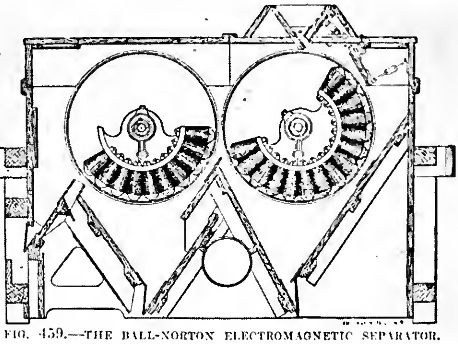


FIG. 459.—THE BALL-NORTON ELECTROMAGNETIC SEPARATOR.

The Ball and Norton electromagnetic separator

Gröndal No. 5. The fourth machine was designed to overcome certain defects that existed in the earlier types, but did not meet with much success, as repair expenses were rather high. The fifth machine is the latest, and has given the best all round results; this separator will be the only one described.

All of the Gröndal separators were designed for wet concentration, that is, the finely ground ore is fed to the machine mixed with water, combining hydraulic classification with magnetic separation.

The Gröndal No. 5[25] consists of a plain brass drum enclosing a series of electromagnets arranged with alternate polarity. This drum is rotated at a speed of 50 to 100 R.P.M., and is so placed that it is just touching or just above the surface of the wet pulp, which traverses a pyramidal box beneath. The finely divided ore is fed into the box at its upper end, meeting a stream of water entering from the bottom, and is washed up over the partition immediately under the drum. The particles of magnetite are lifted out of the water by the magnets inside the drum, and are carried past the field, where they are washed off by a jet of water. The gangue is washed down the other side of the partition and carried off by the waste water. The capacity of one machine is from 50 to 100 tons of ore per 24 hours; it

[25] For information and illustrations of the Gröndal system, I am indebted to Mr. P. McN. Bennie, Niagara Falls, N.Y. The data given is taken from Mr. Bennie's papers on The Gröndal System, read before The Canadian Mining Institute. See Vols. X and XI.

requires about 6 amperes at 120 volts for exciting the magnets and less than one-half horsepower will drive the drums. The drums are usually mounted in pairs, not working conjointly as in the Ball and Norton, but operating singly side by side.

An auxiliary apparatus, also of Gröndal invention, sometimes used in connection with the separators, should be mentioned. By this apparatus the magnetic slimes, formed by the crushers and pulverizers, are saved. Before its introduction most of the iron contained in the slimes was washed away and lost. The essential feature

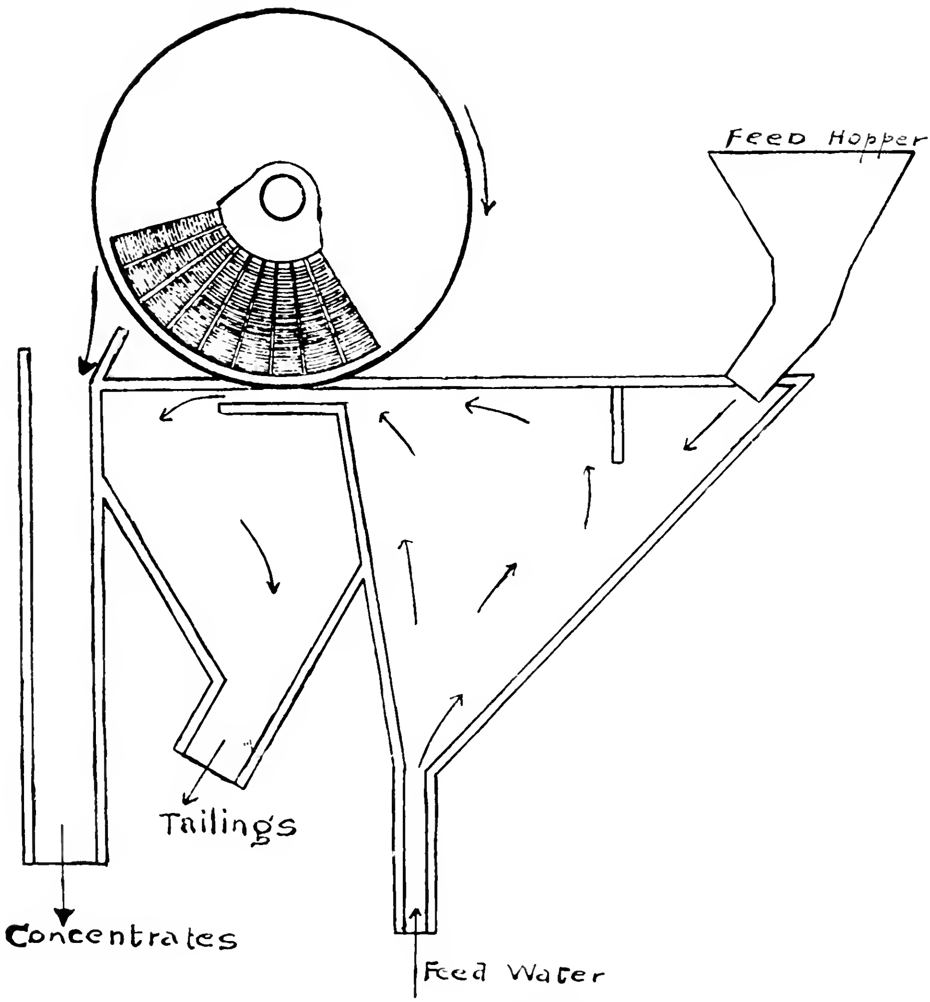
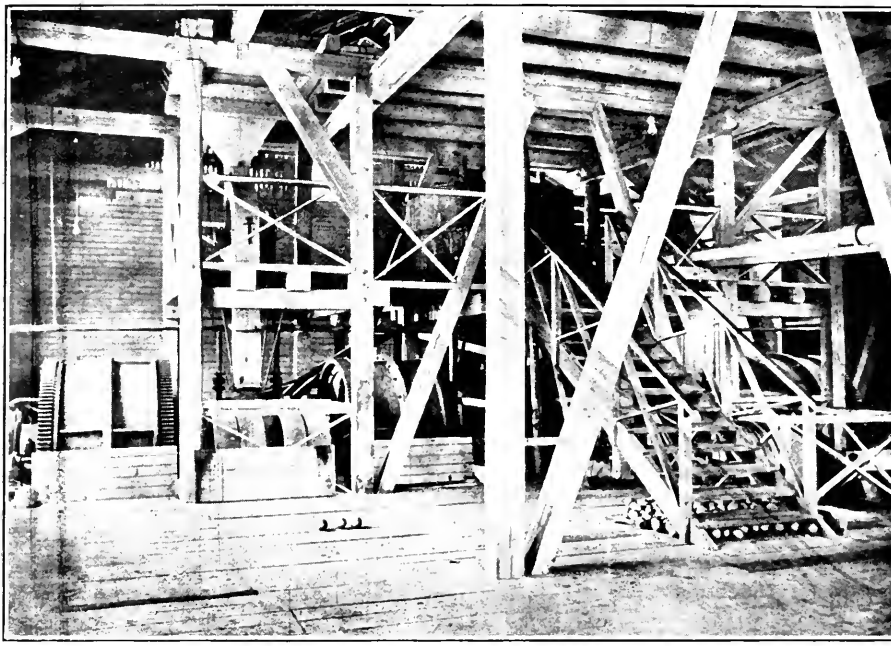
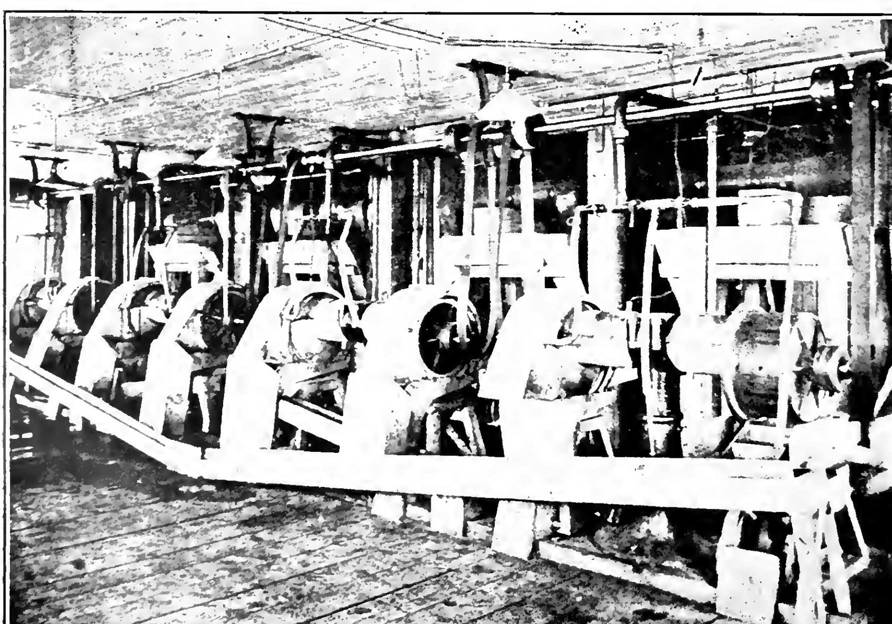


Diagram sketch of the Gröndal separator.

of this slime treater is an electro-magnet with hatchet-shaped pole pieces, suspended over pyramidic boxes. These boxes are kept full of flowing water, and the pulp is feu in at one end. The velocity of the water is so arranged that the heavier particles settle to the bottom at once, the fine slimes pass underneath the poles of the magnets, which are of sufficient strength, just not to lift out of the water, but to collect in bunches the magnetic particles that from time to time sink by their own weight to the bottom of the box, and are drawn off with the main pulp and sent to the separators.



Ball mills at Herrang.



Magnetic separators at Herrang.

The Gröndal system of separating and subsequent briquetting of the fine concentrates is without doubt a very efficient process in the treatment of ores which require much grinding, such as the banded Temagami jaspilytes and the siliceous ores of the Hutton range in Ontario. For this reason a fuller description of the process may be of interest. The method of wet separation is shown in the description of the Lebanon plant contained in this report. But as at Lebanon the concentrates are nodulized and not briquetted as in the complete Gröndal system, a summary of the Gröndal process will be attempted.

Concentrating by the Grondal Process

The scheme of treatment is briefly as follows:—

(1) The ore is crushed dry to about ½ inch cube or thereabouts.

(2) Wet treatment in a Gröndal ball mill, which reduces the ore to from 10- to 100-mesh, as may be found necessary.

(3) The ground pulp is passed through a Gröndal magnetic separator, where the non-magnetic particles are removed.

(4) The concentrates are pressed into briquettes and heated in the Gröndal briquetting kiln, from which they issue as hard, porous, easily reducible, ferric oxide briquettes, with a minimum percentage of sulphur. Any of the standard rock breakers may be used for preliminary crushing. Latterly, the heaviest Blake or Gates type of crushers has been introduced, thus throwing less work on the ball mil's

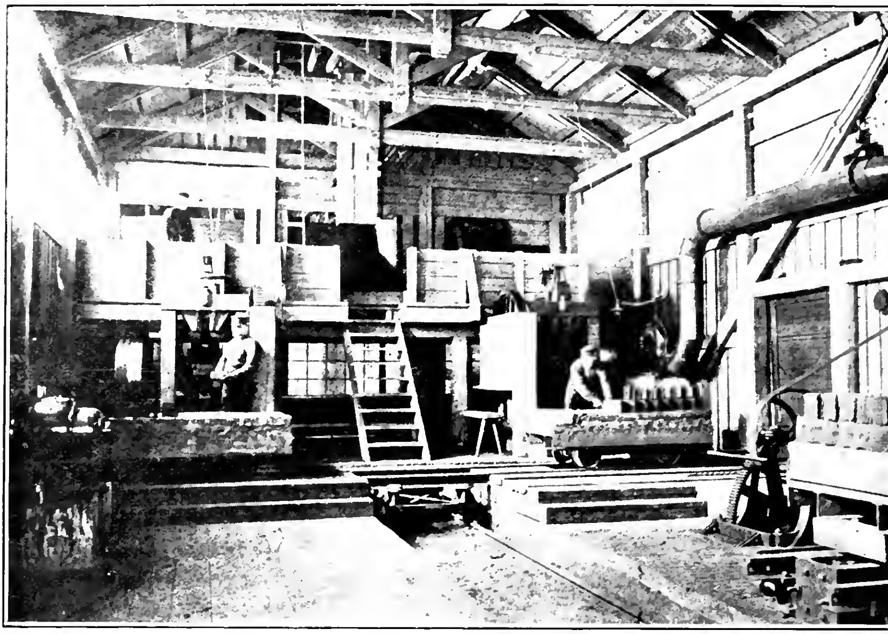
When the ore is of suitable character the use of magnetic cobbing machines is advised, to get rid of such pieces of gangue as contain little or no iron. This reduces the amount of ore to be handled in all subsequent operations per ton of product.

The broken ore is conveyed and distributed to the feed hoppers of the Gröndal ball mills. The feeding arrangement consists of an ordinary roller feeder driven at uniform speed and so constructed as to admit of accurate feed. The ball mills are hollow cylinders 4 feet in diameter and 4 to 8 feet long. They are reinforced with steel ribs and lined with manganese steel or other steel alloy of good wearing quality. The ends are of cast iron with suitable openings provided with a screen at the discharge end. The degree of fineness of the ore is regulated by varying the amount of water introduced into the mill. The mill is charged with about two tons of chilled cast iron balls of about six inches diameter, and it is found that working with ores of average hardness, the consumption of iron, represented mainly by the wear on the balls, amounts to about 2 pounds per ton of ore treated. The mills require from 20 to 25 horsepower each, make from 25 to 30 revolutions per minute, and grind from 50 to 100 tons of ore per 24 hours, depending on the fineness desired. The latest practice is to grind rather finer than was first thought necessary, the practical effect being a higher percentage of recovery and a higher iron content in the concentrates.

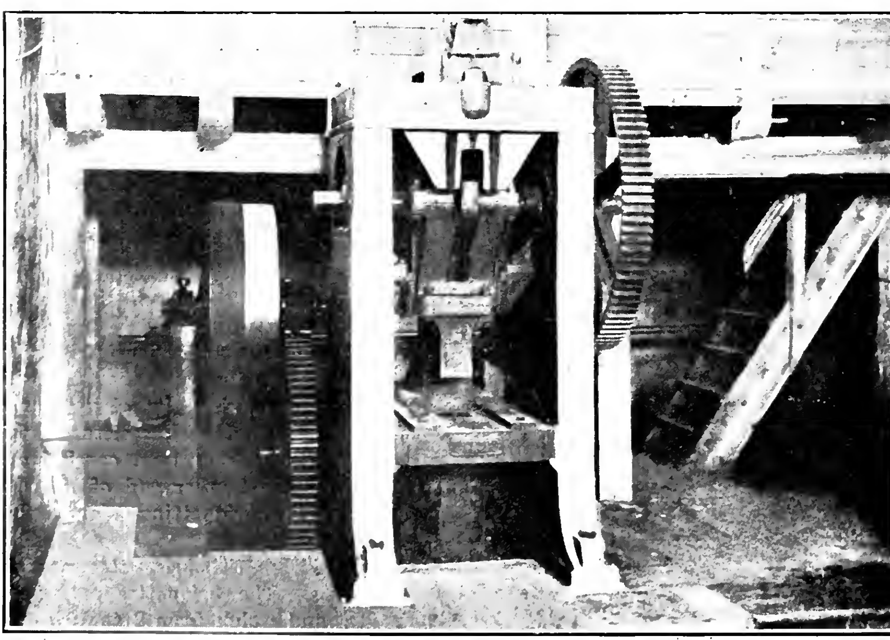
From the ball mills the pulp is sent to the magnetic slimer previously described, or if the amount of slimes is not large, it may go direct to the separators, of which any desired number may be used singly or in pairs as required by circumstances.

The concentrates from the separators are highly saturated with moisture, which in the more recently built plants is eliminated by water separators, consisting of shaking shoes which allow the water to flow away over the further end of the shoe. The partially dried concentrate is then conveyed to the briquetting plant, which consists of a set of drop presses.

The briquetting presses have a drop of 6½ to 7½ inches, the briquettes receiving three blows from a falling weight of about 1,800 lbs. The briquettes may be of various sizes, but are usually made 6 x 6 x 3 inches, and weigh from 8 to 10 pounds each. The pulverized concentrate is pressed into briquettes without any binding material whatever, the contained moisture being sufficient to hold them together



Briquetting plant at Herrang.



Briquetting press.

while they are being removed from the press and taken to the furnace. Each press requires three electric horsepower, and will make from 500 to 750 briquettes per hour. The life of the die plates has been increased considerably, in the latest type of press. At Cwmavon, working pyrite residues, a single set is good for about 500 tons of briquettes.

The Grondal Furnace

To quote from Mr. Bennie:

The briquettes are taken from the press and placed on furnace cars. These are made of iron and covered with fire brick. Along each side of the car is a deep flange which dips into a channel filled with sand placed along the sides of the furnace, thus forming a gas-tight seal. The ends of adjacent cars are fitted with a groove and projecting rib respectively. By this means the surface of the car forms a gas-tight partition and thus prevents the lower portion of the cars, frame, wheels, etc., from becoming heated. The cars measure 3 ft 6 in., and hold from 15 to 16 hundredweight of briquettes arranged on edge in two tiers.

The furnace is fired by gas derived preferably from gas producers, although blast furnace gas can be used. The combustion chamber is situated about one-third of the length from the intake end. The air needed for combustion is introduced below, traversing the row of cars, thus helping to keep the wheels and framework cool, and at the end of the furnace, is diverted to the top of the row of cars, traversing the burnt briquettes, cooling them, and becoming itself heated before reaching the combustion chamber. The products of combustion pass over the entering cars, assist in drying and heating the briquettes, and finally escape through a stack at a temperature of only 150 deg. The furnace being thus constructed on the regenerative principle, has a very good thermal efficiency. Radiation is small, the chief loss of heat being due to the evaporation of the water contained in the briquettes (5 to 7 per cent.) A car of finished briquettes is drawn about every half hour, depending somewhat on the degree of desulphurization required. Recently, furnaces have been arranged so as to give a continuous movement to the cars, increasing the capacity of the furnace considerably.

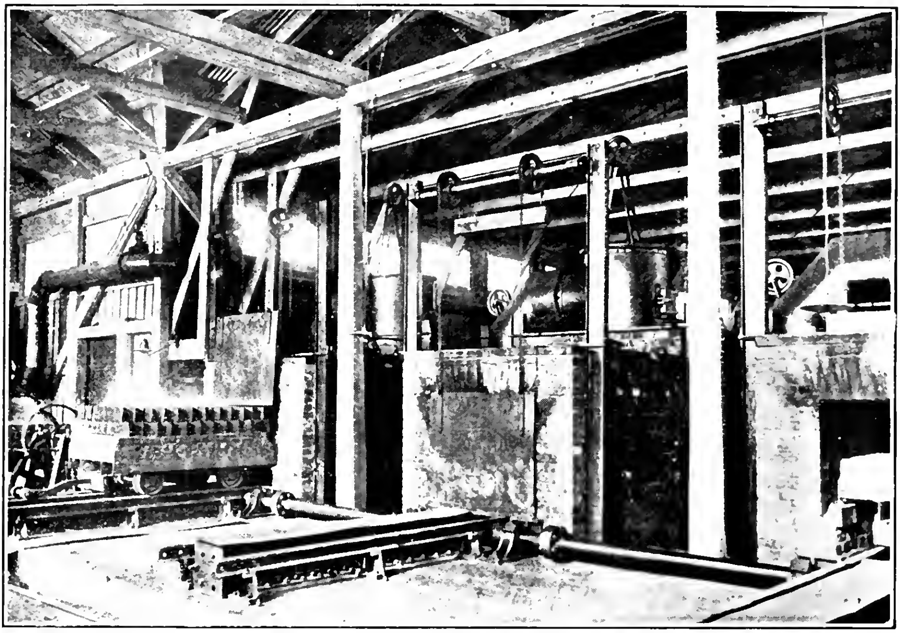
The temperature in the combustion chamber of the briquetting furnace reaches 1,300 deg. to 1,400 deg C. At this heat the particles agglutinate sufficiently to form a firm, hard briquette, able to stand rough handling and long transport. The briquettes though hard, are very porous, and are consequently far more easily reduced in the blast furnace than ordinary lump ore. The briquette made from Herrang ore has a porosity of 23.9 per cent. of its volume.

The output of one furnace varies from 30 to 80 tons in 24 hours, according to the class of ore used, and the degree of desulphurization required: for in addition to its mechanical action this furnace acts as an exceptionally efficient calciner for removing practically all of the sulphur.

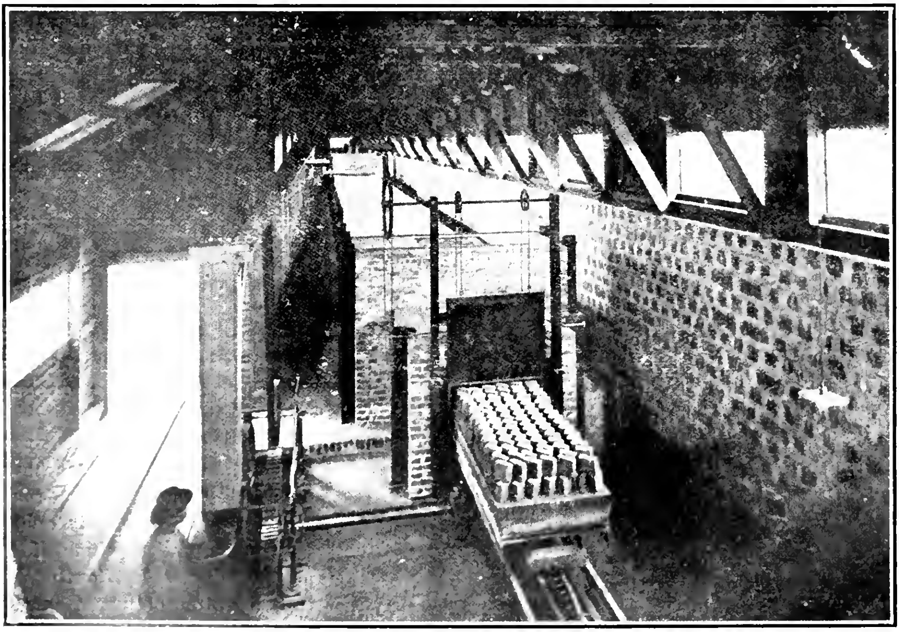
The original briquetting furnaces and cars were one metre wide. It has been found that this may be increased to 1.5 metres without materially increasing the investment. The result of this change is to add 50 per cent. to the daily production of the furnace, approaching the tonnage produced by the nodulizing kiln, and it is expected that the low fuel consumption obtained in the one-metre furnace, will be still further reduced in the wider furnace.

The Gröndal briquette does not contain any added binder, and in the case of magnetic oxide concentrates, the particles are more or less completely peroxidised, owing to the free supply of air entering the furnace during the process of burning the briquettes. Such peroxidised ore (corresponding to hematite) is more easily reduced in the blast furnace than ordinary raw magnetite, and a certain fuel economy is effected thereby.

Briquettes made by this process from pyrites residues and purple ore have proved to be satisfactory in the blast furnace and open hearth steel furnaces. At Cwmavon, pyrites residues containing 2 to 4 per cent. sulphur are being successfully treated by this process. This fact may be of interest to manufacturers of sulphuric acid in Ontario, who are accumulating large piles of their waste material, which if briquetted and burnt as described, would prove a valuable by-product. In South Wales the pyrites residues briquettes command from $5.50 to $6.35 a ton delivered, according to cost of transport; these briquettes contain about 62 per cent. iron and only 0.044 per cent. of sulphur.



Range of Briquetting Furnaces at Herrang.



Briquetting Furnace at Guldsmedshyttan, Sweden.

In Sweden and Norway there exist large quantities of magnetic ores, very similar to our own Ontario magnetites, that contain anywhere from 30 to 60 per cent. of iron, with varying amounts of sulphur and phosphorus. In order to utilize these low grade deposits magnetic concentration is employed on a large scale, and it is stated that every operating company has been financially successful from the start.

Results of Grondal Methods of Concentrating and Briquetting

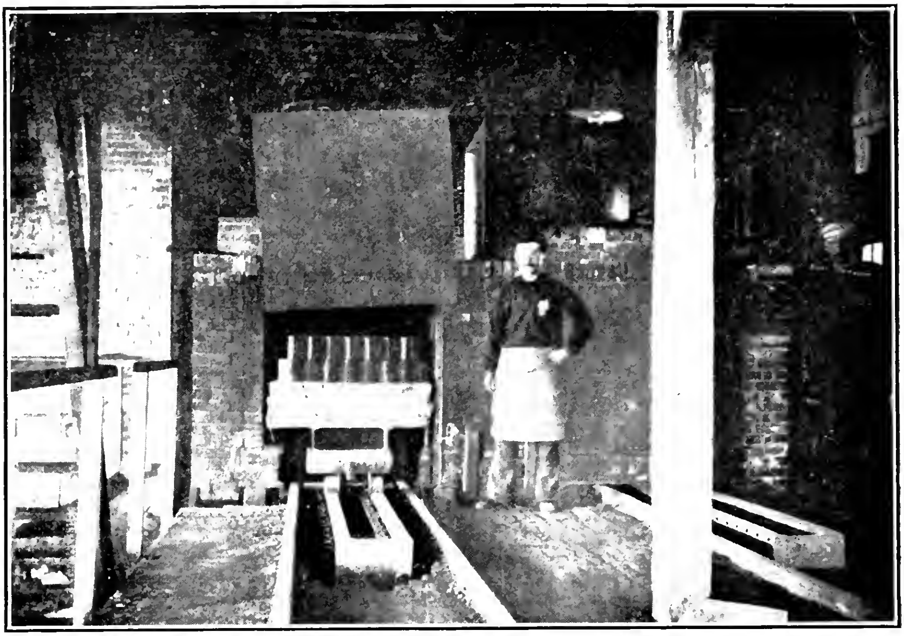
Works.	Crude Ore.			Concentrates.			Tails.	Briquettes.		
	p. c. Fe.	p. c. S.	p. c. P.	p. c. Fe.	p. c. S.	p. c. P.	p. c. Fe.	p. c. Fe.	p. c. S.	p. c. P.
Bredjsö	35.0	0.15	0.010	67.2	0.050	0.004	6.9	65.1	0.020	0.004
Flogberget	27.3	0.31	0.003	67.4	0.040	0.003	7.1	65.3	0.007	0.003
Guldsmedshytten	50.7	3.0	0.003	70.1	0.5	0.002	10 2	68.2	0.010	0.002
Helsingborg (Purple ore)	60.6	0.17	....	....	....	....	....	60.6	0.023	
Herräng	40.2	1.21	0.003	67.3	0.170	0.002	6.4	65.5	0.003	0.002
Hjulsjö	39.7	0.12	0.008	67.1	0.035	0.004	10.1	65.2	0.015	0.004
Loileå	58.2	0.110	1.250	71.1	0.015	0.005	12.0	69.3	0.005	0.005
*Riddarhyttan	52.8	0.025	0.006	64.2	0.017	0.003	7.4			
Salangen	35.7	0.039	0.23	69.3	0.019	0.009	4.9			
Strässa	46.8	0.030	0.015	69.2	0.015	0.003	6.1	67.1	0.005	0.003
Stripa	40.3	0.030	0.010	67.1	0.020	0.002	12.2	67.1	0.005	0.002
*Sydvaranger	38.0	0.066	0.030	68.3	0.026	0.014	5.5	68.0	0.006	0.014
Uttersberg	34.5	0.020	0.024	62.6	0.020	0.016	9.3			
*Vigelsbro	35.2	0.45	0.026	64.6	0.089	0.002	6.7			
Cwmavon (Purple ore)	64.43	1.65	0.019					61.5	0.044	

* Under construction.

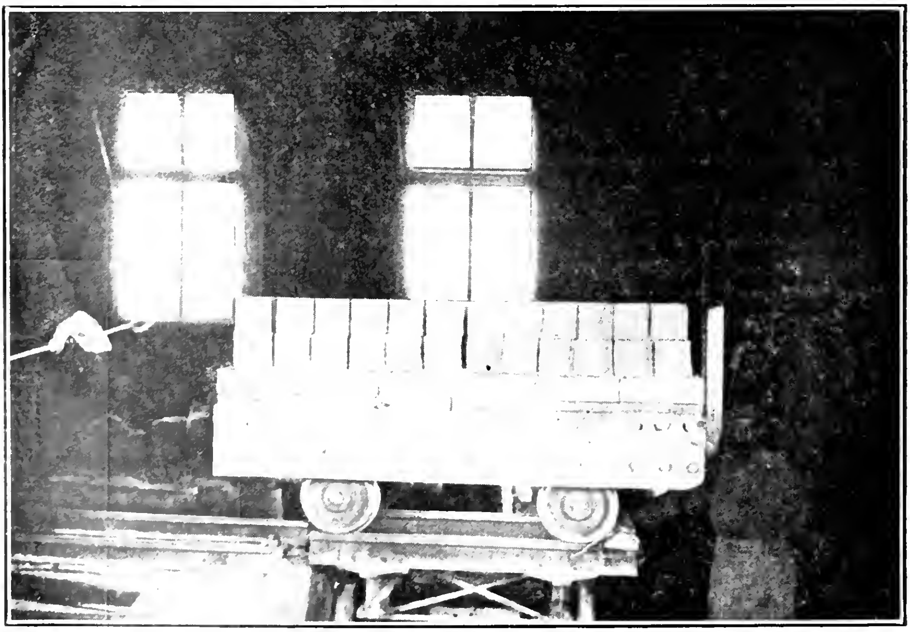
Most of these low grade Norwegian and Swedish ores are very fine grained, requiring much grinding in order to effect an efficient separation, and to keep the iron in the concentrates above 60 per cent. Under such conditions some method of wet separation must be employed. The Gröndal system is extensively used, and is giving good results. In The Engineering and Mining Journal of 11th May, 1907, a list is published of 19 magnetic separating plants actively in operation in Sweden, in 12 of which the Gröndal apparatus is employed.

Following is a list of the works in operation and under construction, in which the Gröndal system is in use or is to be installed. The table shows the annual production.

Works.	Tons Ore Treated.	Tons Concentrates.	Tons Briquettes.
1. Strässa	150,000	75,000	60,000
2. Bredsjö	40,000		20,000
3. Herräng	60,000		30,000
4. Guldsmedshyttan	90,000	45,000	30,000
5. Uttersberg	24,000		12,000
6. Flogberget	50,000		24,000
7. Loileå	60,000		50,000
8. Sandvikens			12,000
9. Horndal			12,000
10. Helsingborg			50,000
11. Cwmavon (Wales)			36,000
12. Alguife (Spain)			40,000
13. Lebanon (United States of America)	200,000	100,000	
Under Construction.			
1. Hellefors	20,000		10,000
2. Vigelsbro	20,000		10,000
3. Salangen	300,000		100,000
4. Sydvaranger	1,200,000		600,000
5. Traversella	50,000		25,000
6. Riddarhyttan	20,000		10,000
Total			1,131,000



Charging car load of purple ore briquettes, Helsingborg.



Car load of burnt purple ore briquettes at Helsingborg.

Where tons of concentrates are not given, the whole output is briquetted. Where only briquettes are given, concentrates or fine or purple ores are used.

In order to obtain accurate information as regards the process of magnetic separation, the writer was instructed to visit several of the large plants in the United States. Accordingly trips were made to the dry separating mills at Mineville and Chateaugay, New York State, and to the plant of the Pennsylvania Steel Company at Lebanon, Pa., where the Gröndal wet system of concentration is employed.

Magnetic Concentration at Mineville, N. Y.

On the eastern side of the Adirondack mountains, and within six miles of Port Henry on Lake Champlain, are situated the historic Mineville group of mines. These mines have been operated since 1846 and have shipped about 15,000,000 tons of ore to date. The largest quantity of rich ore as yet mined in one place in the United States was obtained from the Lover's pit opening on Barton Hill near Mineville. This pit yielded 40,000 tons of magnetite that averaged 68.6 per cent. of iron, with many car loads at 72 per cent.[26] and at the present time the concentrates being produced by Witherbee, Sherman and Company are probably the richest ores sold in America.[27] Being in fine particles they are more easily reduced in the blast furnace than the ordinary lump magnetite, while not nearly so fine as the Mesabi ores from Lake Superior.

The most important of the various ore bodies operated by Witherbee, Sherman and Company are known as The Old Bed, comprising the Joker and Bonanza mines, and The New Bed and Harmony mines. The Old Bed ores are high in phosphorus, carrying from 1.35 to 2.25 per cent., with an approximate iron content of 60 per cent. The New Bed and Harmony ores are low in phosphorus and vary in iron from 40 to 69 per cent. All of the above ores have a more or less coarse crystalline structure, that admits of easy disintegration and consequently very efficient concentration by magnetic separation. The gangue associated with the ores consists of apatite, silica and hornblende, the proportion of gangue matter varying considerably in the ores from the several mines. The apatite varies in color and in size of crystals, and when these crystals are of a deep red color they develop sufficient magnetism to carry them into the iron concentrates. They also have a tendency to adhere to the crystals of magnetite, much more so than the yellow or green varieties, which display much less magnetic susceptibility.

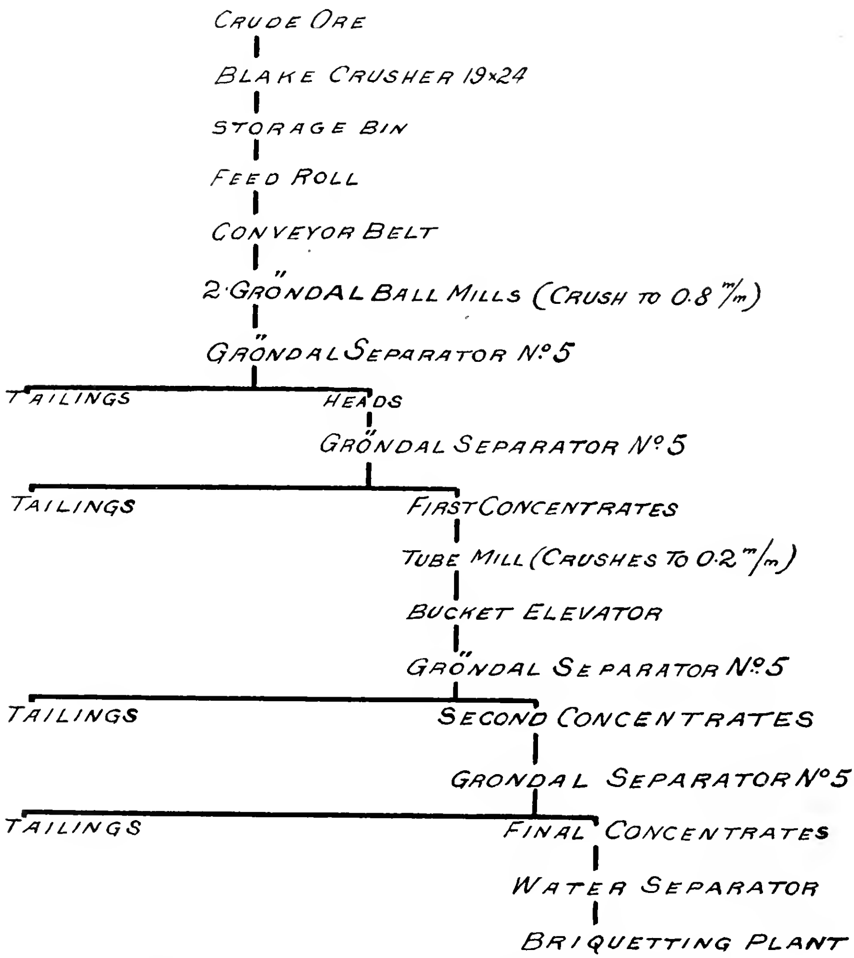
Magnetic concentration is carried on in the two mills shown in the accompanying photograph, the upper or No. 2 mill treating the high phosphorus ores from the Old Bed mines, and the lower or No. 1 mill treating the crude ores from the Harmony mine and also the tailings from a magnetic cobber which is installed at the Harmony shaft.

The cobbing plant at the Harmony shaft was erected to concentrate the ore in large sizes, the product being a coarse magnetite running about 61 per cent. in iron. This is shipped directly for blast furnace use, to mix with the finer concentrates. The cobbing plant is very simple and may be described as follows:—The mine skip dumps into a chute feeding a 30 x 18-inch Blake crusher, which breaks the ore down to 1½ inch size; it is then conveyed to a Ball and Norton single drum magnetic separator, the cobbed product and tails being taken by two Robins belt conveyors to storage bins. The cobbed ore, as already stated, is shipped direct, and the tailings trammed to No. 1 mill where they are re-treated by finer grinding and secondary concentration.

[26] Ore Deposits of the United States and Canada, by J. F. Kemp, p. 85. [27] The Iron Age, December 17, 1903.

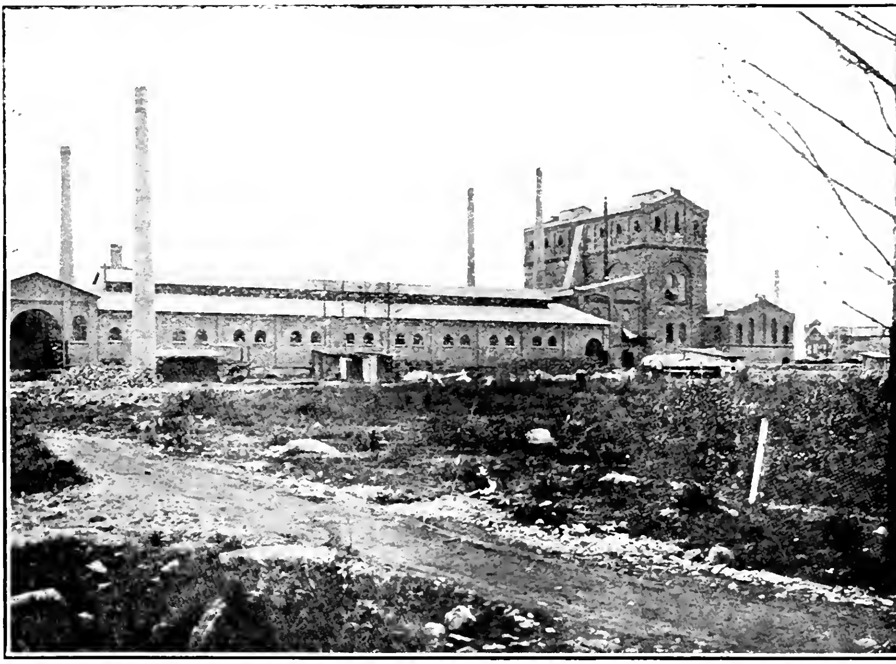
No. 1 Mill

At No. 1 mill the crude ore from the Harmony mines and tailings from the cobbing plant are dumped and weighed, passing into a storage bin which feeds a 30 x 18-inch Blake crusher, and are afterwards screened to ¾ inch size, the fines passing to a dryer, the oversize going to a Gates crusher size H., then joining the stream of fines, all go to the dryer. This is a square, vertical brick stack, with cast iron tees arranged in alternately staggered sections: the ore being fed in at the top

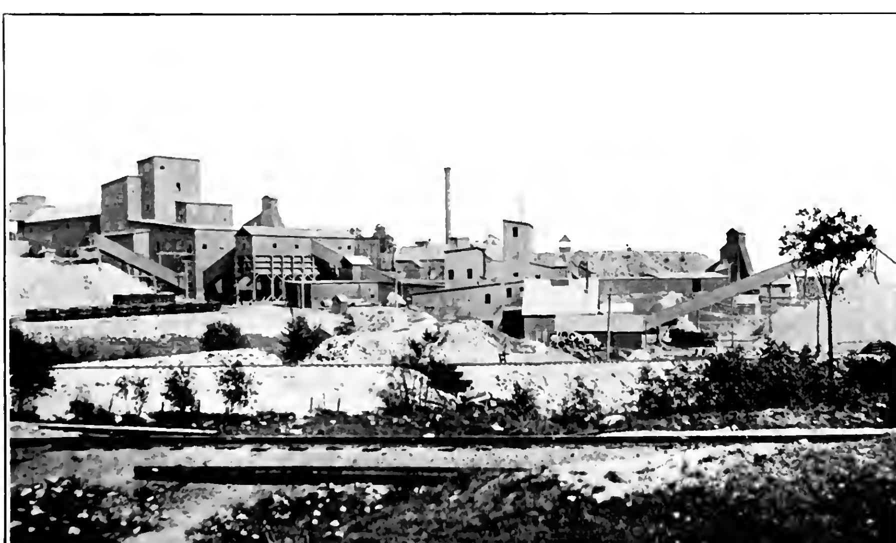


Flow sheet of Grondal concentrating plant, Flogberget, Sweden.

falls over the bars, admitting free circulation of hot air and gas throughout the mass. At the bottom, the dryer is connected with an outside coal-fired furnace, the product of combustion passing over a bridge wall into the stack. The ore discharged from the bottom of the dryer is then fed to a Ball and Norton single drum magnetic cobber, the heads passing to the shipping bins and the tails being re-ground in a pair of 40 x 15-inch Anaconda rolls, thence elevated and passed over a 3-8-inch tower screen. The undersize from the tower screen goes to two Ball and Norton belt separators (of the type already described). Concentrates from these machines are carried by belt conveyor to the shipping bins, while the tailings are reconcentrated by



General view of Herrang Iron works, Sweden.



No. I. and No. II. Mills, Witherbee Sherman Company, Mineville, N.Y. Combined mills handle 1,600 tons crude ore in 10 hours, producing 1,360 tons of concentrates.

another pair of similar separators, operating on a heavier electric current, and removing the last of the magnetite down to the economical point, the tailings going direct to the dump. The oversize from the tower screen is passed through a pair of 36 x 14-inch Reliance rolls, and final concentration is made by two other Ball and Norton belt separators, the heads product being carried to the shipping bins and the tails joining the waste from preceding operations are carried to the dump by a 20-inch Robins belt conveyor.

The power for No. 1 mill is furnished by four 50-h.p. Crocker-Wheeler direct current motors, and a single 75-h.p. General Electric induction motor. The conveyors and light machinery are run by belting from the motor room, which is built as a part of the mill but divided off in order to keep out dust and grit.

The results of concentration at No. 1 mill are shown by the following analyses[28]:—

	Iron per cent.	Phosphorus per cent.
Crude Harmony Ore	50.26	0.292
Harmony Concentrates	64.10	0.133
Harmony Tailings	13.97	0.877

Tailings from this mill are used for the manufacture of concrete blocks. A large new general office has been erected of this material at Mineville, and several other substantial buildings have been made of these concrete blocks.

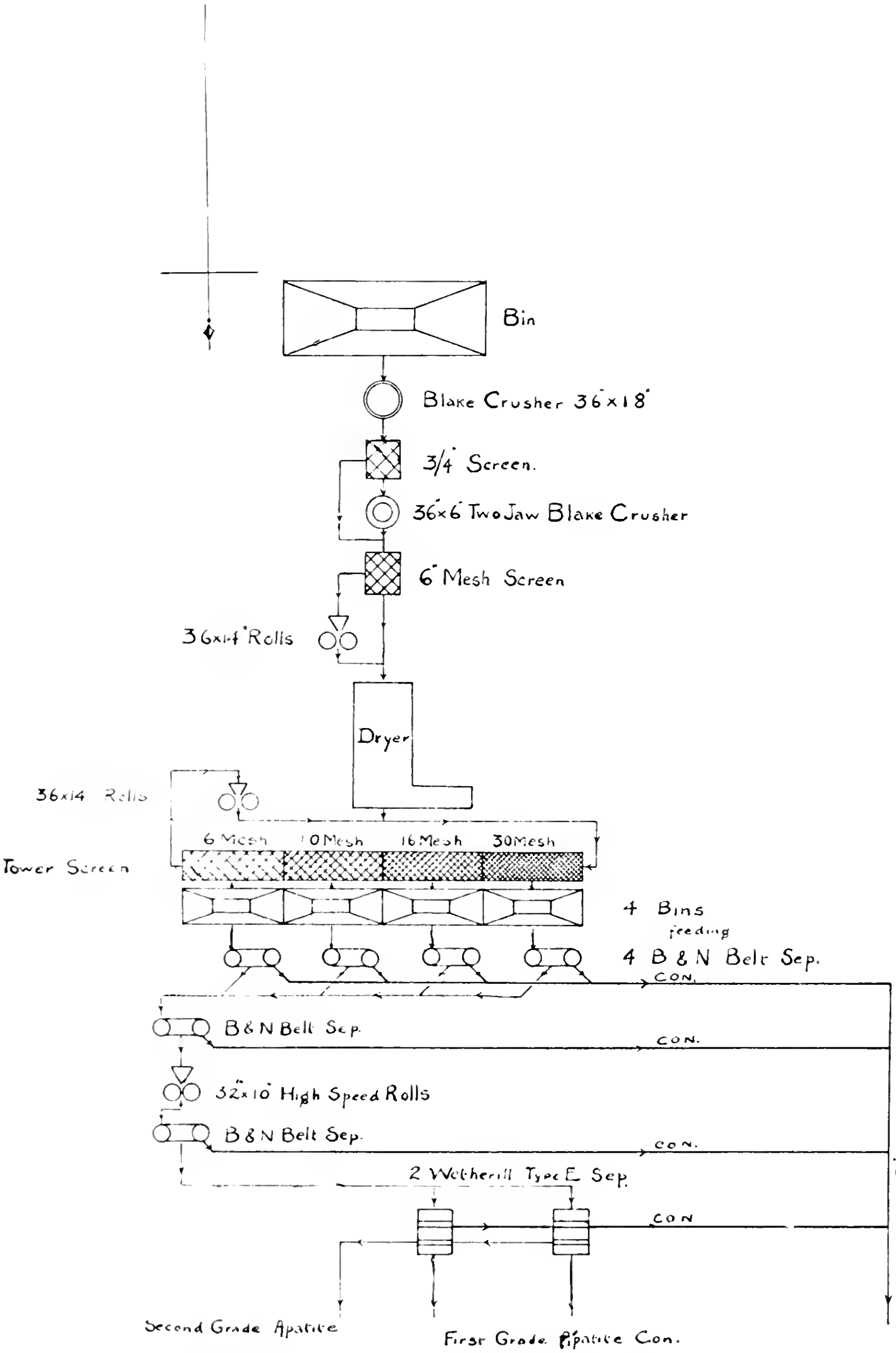
No. 2 Mill

No. 2 mill treats the high phosphorus Old Bed ores, and although the general treatment is similar to that described for No. 1, there are several interesting features that invite attention.

A flow sheet of this mill is shown, which brings out the essential points of difference between it and No. 1. The ore is first crushed to 1½-inch size in a 30 x 18-inch Blake crusher and then passed over a ¾-inch screen, oversize being broken to ¾-inch by a 36 x 6-inch two jaw Blake crusher, the undersize and the crushed product going to a six-mesh screen. The oversize from this screen is fed to a set of 36 x 14-inch Reliance rolls and is then united with the undersize, and all passes to a dryer of the same kind as described in No. 1 mill. From the dryer the ore is elevated to a tower screen of 288 square feet of screening area. This screen is divided into equal sections of 30-, 16-, 10- and 6-mesh, the finest mesh being of course at the top. The product of these screens is delivered to four separate bins, the oversize, passing to a set of 36 x 14-inch Reliance rolls, is crushed and then returned to the main stream from the dryer. Under each bin is placed a Ball and Norton belt separator, the concentrates from these machines going direct to the shipping bins. The tailings are re-treated by a single belt machine operating with a slightly stronger electric current, the concentrates joining the main stream from the first four separators, and the tailings being ground in a pair of 32x10-inch Traylor high speed rolls, feeding to another Ball and Norton belt separator. The concentrates are again diverted to the main stream, the tailings passing to two Wetherill type E. magnetic separators. The Wetherill machines make three products, first, iron concentrates; second, tailings consisting of hornblende and some of the magnetic apatite mentioned above, and third, non-magnetic apatite with silica in pure white grains. The iron concentrates are conveyed to the iron concentrate bin, and the apatite cocentrates and tailings, both valuable products, are conveyed to separate bins.

Power for No. 2 mill is supplied by three 60-h.p. General Electric induction motors for the heavy machines, and one 10-h.p. General Electric induction motor for the conveyors running to the shipping bins. All motors are protected as much as possible from grit and dust.

[28] All analyses taken from The Engineering and Mining Journal, June 23rd, 1906.



Flow sheet of No. 2 mill ; Witherbee Sherman & Company, Mineville, N.Y.

The three products from No. 2 mill are magnetite or iron concentrates, first grade apatite concentrates, and second grade apatite or poultry grit.

Analyses of the crude ore and resulting products are as follows:—

——	Iron. p.c.	Silica. p.c.	Phos. p.c.	Lime p.c.	Sulphur. p.c.	Bone Phosphate. p.c.
Crude Old Bed Ore	59.59	....	1.74	....	....	....
Old Bed Concentrates	67.34	2.20	.675	3.14	trace.	....
First Grade Apatite	3.55	18.61	12.71	....	....	63.55
Second Grade Apatite	12.14	....	8·06	....	....	40 30

A fourth product made occasionally for special purposes is that known as re-treated concentrates. This is an exceptionally pure magnetite which will average 71.85 per cent. in iron. (Theoretical magnetite carries 72.40 per cent. of iron.) One shipment of this material has been made to the General Electric Company for use in their magnetite lamp.

The combined capacity of the two mills is 1,600 tons of crude Old Bed ores in 10 hours, yielding 85 per cent. or 1,360 tons of concentrates. Treating Harmony and New Bed ores, the mills will handle 1,200 tons per 10 hours, of which 77 per cent. or 924 tons is recovered as concentrates. About 65 per cent. of the finished product is larger than 10-mesh, which makes it a very desirable material for blast furnace use.

The economical recovery is less than the point to which recovery might be carried, and while Harmony and Old Bed concentrates run respectively, 60 and 65 per cent. iron, the iron content could be raised 5 or 10 per cent. if desired; but if concentration is carried beyond the averages given above, the additional iron saved would be obtained at the expense of the granular character of the concentrates. That is, finer crushing would be necessary, and the resulting concentrates would then not be so desirable from the furnaceman's point of view. This point is well brought out by the frequent screening of the material during its passage through the mills, the object being to avoid pulverization as far as possible. Much experimenting to determine the economical point of recovery has been carried on by Mr. S. Norton, general manager of the plant, to whom thanks are due for information and courtesies received.

Cedar Point Furnace, Port Henry, N.Y.

At Port Henry the Cedar Point furnace is operated under lease by The Northern Iron Company, and as Mineville ores are almost exclusively used at this plant, a few notes on the furnace practice may be of interest.

Most of the output is basic pig iron, of which about 5,000 tons are produced monthly on an average coke consumption of 2,300 lbs. per ton of iron. A typical analysis of the iron is as follows: Silicon, 0.63; Sulphur, 0.008; Phosphorus, 0.85.

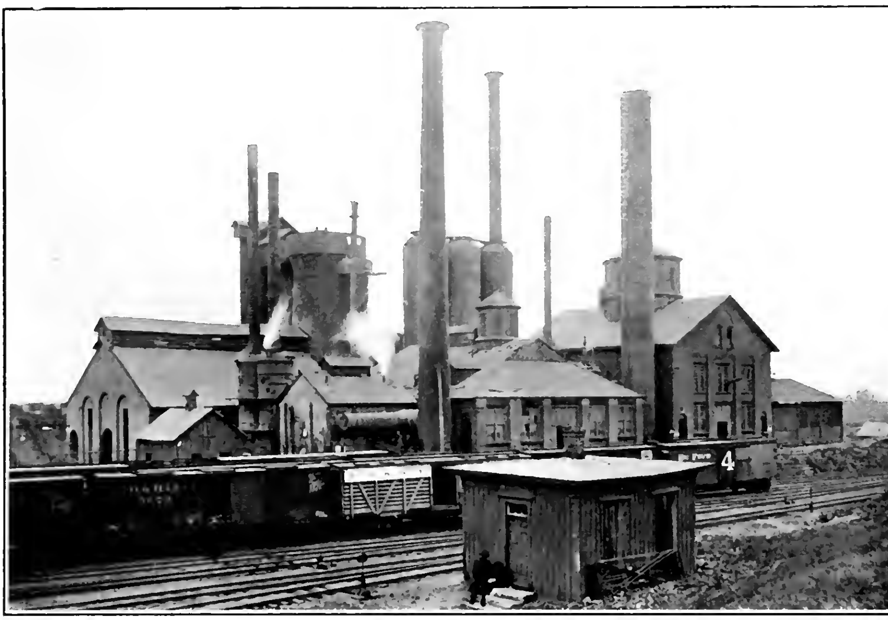
The furnace is 69 feet 3 inches in height by 17 feet diameter at the bosh, and 16-foot hearth, with 11 feet 6 inches at the stock line. The hearth is pierced for 9 tuyeres, the blowing engines supplying 18,000 cubic feet of air per minute, which is heated to approximately 1,000 degrees Fahrenheit, the average blast pressure being $8\frac{1}{2}$ pounds per square inch. The ore charge consists of 13/16 to 15/16 of concentrates, the balance of the charge being Old Bed crude ore, and is delivered to the furnace from a double section bell, which is a modification of the F. Firmstone pattern. Both the outer and inner sections of this charging bell are adjustable through certain limits. At the time of my visit the outer section or ring had a drop of 24 inches, while the drop of the central portion was adjusted to 6 inches. This arrange-

ment is found to work satisfactorily, giving a uniform distribution of fine and coarse ore at the stock line, and by means of the adjustments before mentioned this distribution can be varied at will.

The stock is charged as follows:—

Coke Charge, approx................	4,800 pounds.	
Ore Charge, approx..................	8,200 "	
Limestone Charge, approx.........	2,460 "	varying between 28 and 32 per cent. of the ore charge.

The slag made is rather basic, containing approximately silica 34 per cent., alumina 12 per cent., and 12 to 14 per cent. of magnesia; the balance may be considered as practically lime. On account of the rich ores, low in sulphur, the furnace is run rather dry with respect to the amount of cinder made, the slag volume being very low.



Port Henry furnace, N.Y., where Mineville concentrates are used.

The furnace works smoothly with practically no tendency to hang or slip, and the manager Mr. F. E. Bachman, to whom thanks are due for most of this information, has no difficulty in keeping the output at 180 to 200 tons of iron daily.

Concentration Works at Lyon Mountain, N.Y.

The Lyon Mountain or Chateaugay mines are situated in the northeast corner of the Adirondack mountains, New York State, about 36 miles west of Plattsburg on the Delaware and Hudson Railway, and are operated by the railway company.

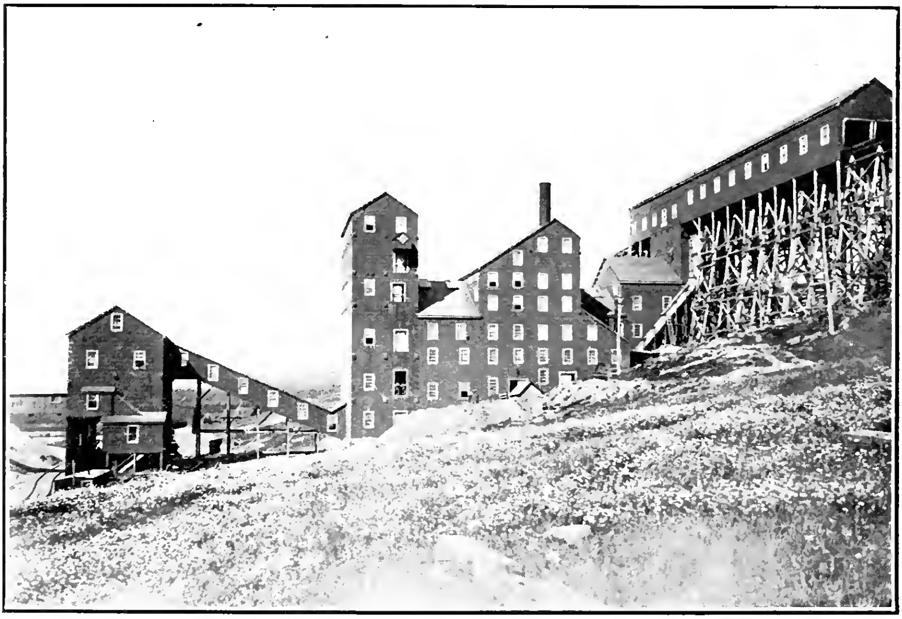
The mines have been worked since 1867, and the total production of ore up to the present time may be placed approximately at 4,100,000 tons. Some years ago a considerable amount of the run of mine ore was shipped, but at the present time the total output of the mines is submitted to magnetic concentration and shipped only as concentrates.

The character of the ore varies considerably, but the average grade consists of about equal proportions of magnetite and gangue minerals, the latter consisting chiefly

of feldspar, quartz, and pyroxene. Phosphorous and sulphur are both low, and as the ore is fairly coarse-grained (although not as coarse as the Mineville ore) the problem of concentration is not difficult. The iron contents will vary between 25 and 50 per cent., but the average will run 32 per cent. or thereabouts.

There are two mills at Lyon mountain, the old and the new. The old mill was designed for ordinary wet concentration about 20 years ago, but was afterwards re-built and arranged for dry magnetic concentration. Many changes were made, and new machinery was added at various times until the operation of the mill became very complicated, with high costs for power and repairs. When the new mill was built in 1905-1906, operation of the old plant was discontinued.

The new mill, designed by the Allis-Chalmers Company of Chicago, who also supplied nearly all of the machinery, is built of Georgia pine on solid concrete founda-



Concentrating Mill at Lyon Mountain, N.Y. Mill handles 1,800 tons crude ore per 24 hours, and produces 500 tons concentrates,

tions carried up from bed rock. An exterior view of the mill is shown, and it can be seen that the buildings are constructed on a large scale.

The capacity of the plant is from 1,000 to 1,200 tons of crude ore per 24 hours, producing on an average 500 tons of concentrates that have an iron tenor of over 60 per cent. As the ore must be crushed down to ¼-inch to obtain the best results in separation, the crushing machinery is of extensive and costly design. The ore is concentrated dry, and the Ball and Norton double drum magnetic separators are used exclusively. These separators are giving good results, as the accompanying analyses will show. Each machine is supposed to have a rated capacity of 15 to 20 tons of crude ore per hour. A description of this type of magnetic separator is given elsewhere in the report.

Analyses of Chateaugay Crude Ores, Concentrates and Tailings

——	Crude Ore. per cent.	Concentrates. per cent.	Tailings. per cent.
Ferric Oxide	31.48	60.128	4.57
Ferrous Oxide	15.81	28.850	3.60
Manganous Oxide	0.115	0.107	0.124
Silica	33.16	6.880	58.56
Alumina	4.90	0.900	10.72
Lime	4.96	0.660	8.24
Magnesia	2.10	0.450	4.06
Phosphoric acid	0.043	0.023	0.064
Sulphur	0.027	0.022	0.035
Titanic acid	0.427	0.417	0.457
Ferrous Oxide in gangue	2.83	0.257	4.76
Potash	1.408	0.494	1.61
Soda	2.283	0.777	2.99
Moisture	0.25	0.040	0.12
	99.793	100.005	99.910
Total iron	36.50	64.72	9.70
Iron in magnetite	34.30	64.53	6.00
Phosphorus	0.019	0.010	0.028
Manganese	0.089	0.083	0.096
Titanium	0.256	0.250	0.274

The mill consists of three sections each of which is operated separately. First, crushing and drying; second, screening and grinding; and third, magnetic concentration. Each section has a large storage bin, and in case of a break down in any part of the mill, it is possible to keep the other sections running. A sketch diagram of the process is shown and by reference to the numbers attached, the passage of the ore can be followed through the mill.

Crushing and Drying

The crude ore is brought from the mines in 6-ton side or bottom dump cars, and after being weighed is discharged into a storage pocket holding 800 tons. From the bottom of this pocket the ore passes to a 24 x 30-inch Blake jaw crusher. This crusher is one of the largest built, and weighs 31 tons. The crushed ore from the Blake reduced to 5-inch size is then passed over a 1½-inch grizzly to a No. 7 K. Gates gyratory crusher, which delivers it in 1½-inch size to a conveyor belt which also receives the fines that passed the grizzly, and carries all to 40 x 30-inch enclosed rolls of the Allis-Chalmers Anaconda type. These rolls crush the ore to ¾-inch and feed to a bucket elevator that conveys the ore to the top of a vertical dryer of a modified Kowand type. The ore drops through the dryer a distance of 40 feet, between T iron bars that are placed in staggered position, meeting the hot gases from the coal fired furnace below, and comes out at the lower end, where it is picked up by another bucket elevator and conveyed to a second storage bin of 300-ton capacity. It should be noted here that this dryer at the time of my visit was not giving satisfaction. The dried ore was hardly warm, notwithstanding the fact that all ore cars in transit from the mines to the mill are covered with canvas blankets to protect the ore from excessive moisture in bad weather.

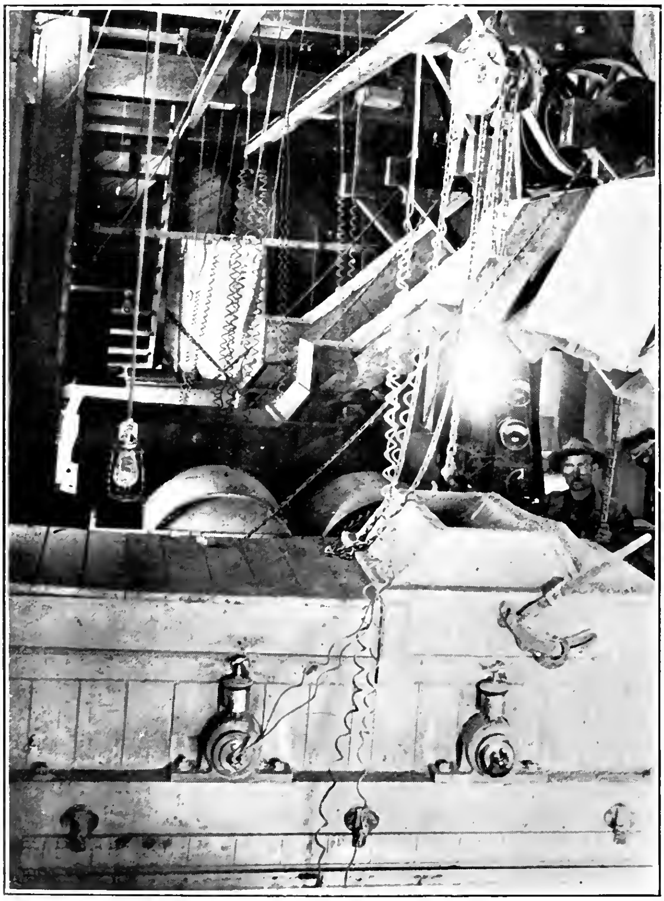
Screening and Grinding

The trommel screens are fed from the second storage bin, the ore passing over ordinary roll feeders. These screens are of the revolving type and are 16 feet long by 4½ feet in diameter; all are driven by bevel gears at the discharge end. Two of the screens are double jacketted, the inner shell perforated with ¾-inch and the

outer with ¼-inch taper holes. The two single screens also have ¼-inch perforations. The oversize and ¾-inch material from the double screen, is delivered to two 40 x 15-inch rolls, of the same type as the large crushing rolls, and is then elevated to the single screens, the oversize from these being returned to another pair of 40 x 15-inch rolls, and the undersize elevated to a third storage bin placed above the magnetic separators.

Magnetic Concentration

The fine ore from the bin is fed directly to four primary Ball and Norton separators on the top floor of this section. The middlings and tails are re-crushed in four



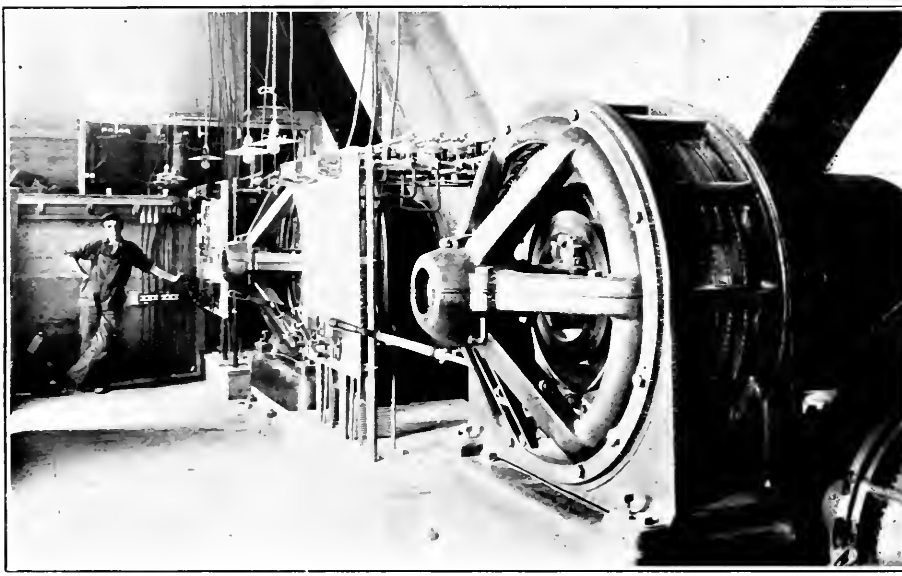
Double drum Ball and Norton magnetic separators in the Lyon Mountain concentrating mill.

sets of small rolls, two grinding middlings and two grinding tailings, and are then retreated in four secondary separators on the next floor below. The middlings from this secondary set are returned by elevator to two of the rolls mentioned above, while the tailings are sent to a final separator where the last of the magnetite is removed. The middlings from this final machine go back through the tailings rolls again, and the final tailings with the final concentrates are conveyed by two parallel belts to the storage pockets.

The speed of rotation of the Ball and Norton drums varies according to the class of ore being treated. Ordinarily, the first drum has a speed of 40 R.P.M. with an

exciting current of 16 amperes, while the second drum is rotated at 120 R.P.M. with an exciting current of 6 amperes, at 220 volts. The following figures are of sieve tests, and show that the concentrates are of nearly uniform mesh from day to day.

1906.	Aug. 4. p.c.	Aug. 6. p.c.	Aug. 7. p.c.	Aug. 8. p.c.	Aug. 9. p.c.	Aug. 10. p.c.
100 mesh	16.9	16.6	17.2	17.8	16.9	14.7
80 "	2.5	2.2	2.5	1.3	2.8	3.1
60 "	7.8	8.4	7.2	7.2	6.6	6.6
40 "	17.5	18.4	19.1	18.7	18.7	18.1
20 "	26.2	26.2	26.6	26.6	26.6	25.9
10 "	23.2	21.6	20.9	21.2	21.9	23.4
Above 10	5.9	6.6	7.5	7.2	6.5	8.2
Total	100.0	100.0	100.0	100.0	100.0	100.0



Motor room in the Lyon Mountain concentrator.

The belts which convey the concentrates and tailings away from the separating section are 20 inches wide and run side by side up a 23½-degree incline to the shipping pockets. The concentrate pocket has a capacity of 600 tons and delivers through bottom chutes directly to the railroad cars below. The tailings are passed over a revolving screen with ⅛-inch holes separating the coarse from the fine grit; the undersize goes to a bin holding 200 tons, and is shipped for use as locomotive sand, being dry, sharp and clean. The coarse tailings are conveyed to the tailings dump and are utilized for railroad ballast, also for making concrete. Many of the dwellings in Lyon mountain are constructed of concrete blocks made from the tailings sand.

The power required for driving the mill is supplied by two 225-h.p., 1,040 volts, 3-phase current induction motors. The current for the magnetic separators is furnished by a 50-h.p. motor generator. When the mill is running it requires about 580 h.p. to keep it operating under full load.

Sixteen men only are required per shift to operate the mill; their occupations are as follows:—

	Per 12 hours.	Per 24 hours.
Dump and weigh crude ore	2 men	4 men
Crushers and rolls	4	8
Magnetic separators	3	6
Fireman for dryer	1	2
Motor room	1	2
Oiler	1	2
Sampling	1	2
Load and weigh concentrates	2	4
Foreman	1	2
Totals	16 men	32 men

For the above information, thanks are due to Mr. J. H. Cartwright, General Superintendent, to Mr. Frank Davies, foreman of the mill, and to Mr. James Brakes, chemist for the company, who supplied the analyses and sieve test data.

A considerable tonnage of the Chateaugay concentrates is shipped to Standish, 5 miles from Lyon mountain, where the Northern Iron Company is operating a small blast furnace, and accordingly a trip was made to this plant in order to ascertain if possible what effect the use of such fine concentrates would have on the working of the furnace.

Tree of the Concentrating Process

Cars from mine deliver ore to (1).

(1) Bin, capacity 800 tons, to (2).

(2) Blake crusher size 24x30, crushing to 5 inch, to (3) and (4).

(3) Grizzly screening to 1½-inch, to (4) and (5).

(4) Gates crusher No. 7 K. crushing to 1½-inch, to (5).

(5) Belt conveyor to (6).

(6) Anaconda rolls 40x30-inch crushing to ¾-inch to (7).

(7) Bucket elevator to top of (8).

(8) Rowand dryer to (9).

(9) Bucket elevator to (10).

(10) Storage bin, capacity 300 tons, to (11).

(11) Two double revolving screens ¾-inch inside, ¼-inch outside, yielding oversize to (12) and undersize to (17).

(12) Two 40x15-inch rolls to (13).

(13) Belt conveyor to (14).

(14) Bucket elevator to (15).

(15) Two revolving single screens ¼-inch, yielding oversize to (16) and undersize to (17).

(16) Two 40x15-inch rolls to (13).

(17) Belt conveyor to (18).

(18) Bucket elevator to (19).

(19) Storage bin feeding to (20).

(20) 4 Ball and Norton double drum separators yielding concentrates to (27), middlings to (21) and tailings to (26).

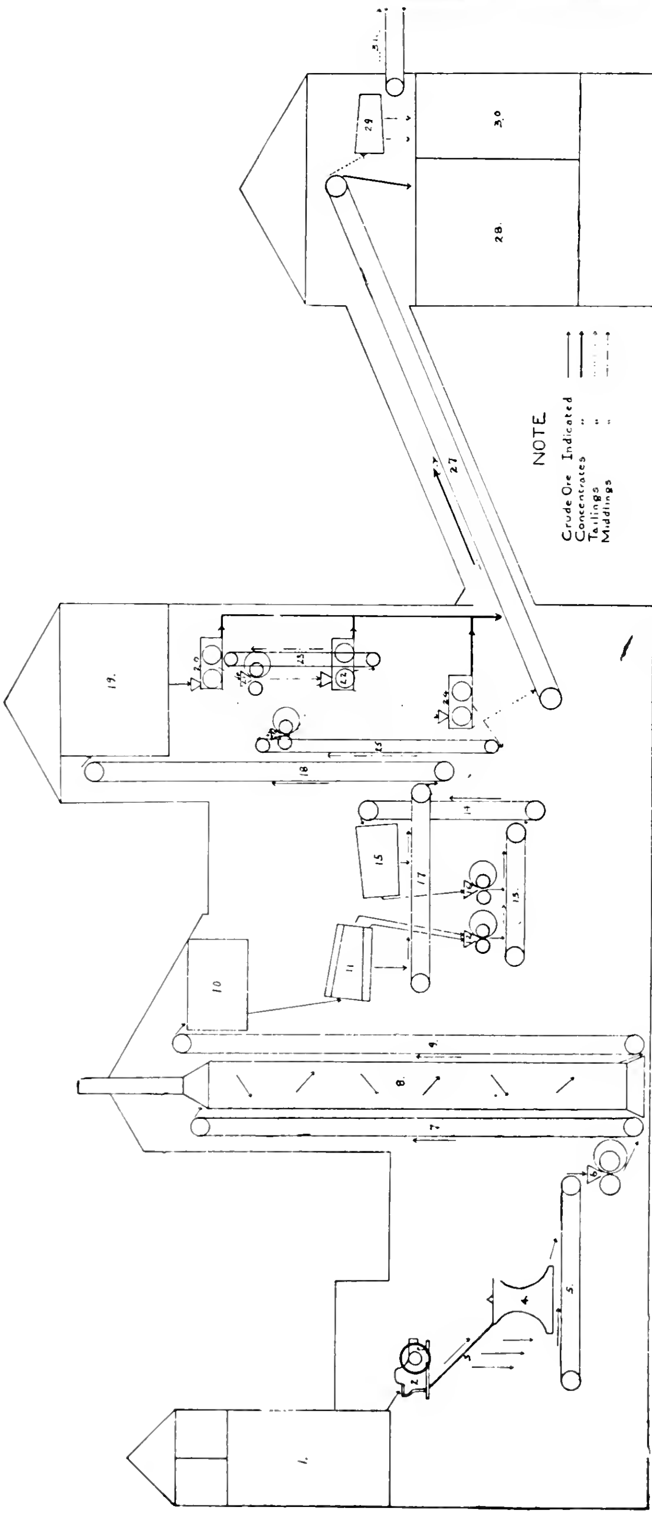
(21) 2 pair small crushing rolls to (22).

(22) 4 Ball and Norton double drum separators yielding concentrates to (27), middlings to (23) and tailings to (24).

(23) Bucket elevator to (21).

(24) 1 Ball and Norton double drum separator, yielding concentrates to (27), middlings to (25) and tailings to (27).

(25) Bucket elevator to (26).



Diagramatic section of magnetic separating mill at Lyon Mountain, N. Y.

(26) Two pair small crushing rolls to (22).

(27) Two parallel conveyor belts, for concentrates to (28) and tailings to (29).

(28) Concentrate shipping pocket.

(29) Revolving screen with ⅛-inch holes, yields locomotive sand to (30) and coarse tailings to (31).

(30) Shipping pocket for locomotive sand.

(31) Belt conveying coarse tails to waste dump.

Standish Furnace, N.Y.

From the accompanying photographs a general idea may be had of the extent of this plant, and therefore no detailed description of the furnace will be attempted.

The stack 90 feet high, with a 15.5-foot bosh and 9.5-hearth, is blown through eight 5-inch tuyeres, about 18,000 cubic feet of air being delivered per minute at a pressure of 12 to 15 lb. per square inch, with a blast temperature of 1,000 degrees Fahrenheit.

The ore charge averages 60 per cent. of iron, but on account of the loss in flue dust, does not yield more than 58 per cent. of pig metal. The total charge of coke, ore and stone is as follows:—

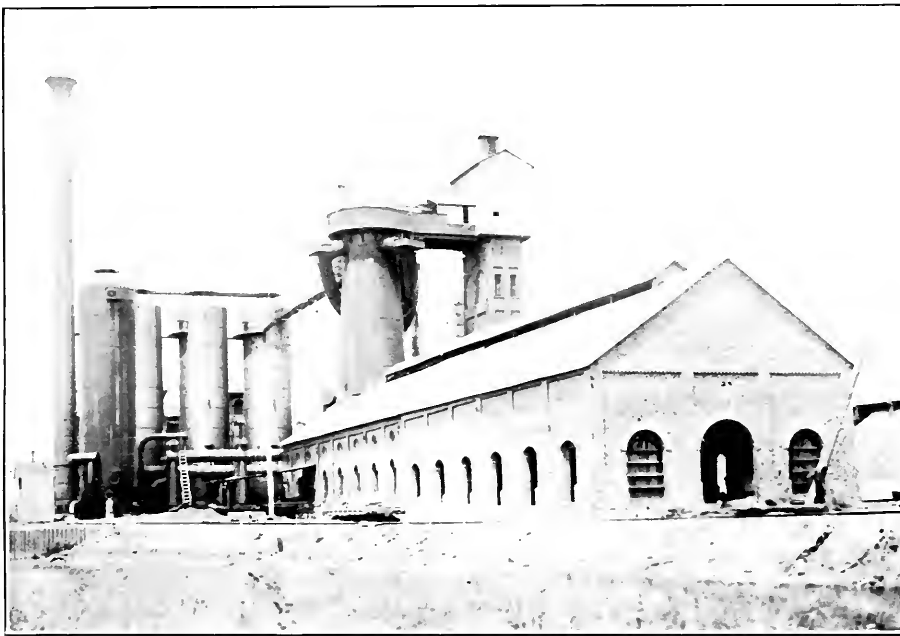
Coke	5,000 lbs.		
Ore	8,000 lbs.	=	1.6 lbs ore per pound of coke.
Limestone	2,800 lbs	=	35 per cent. of ore charge.

The slag which is found by experience to give the best results contains 50 per cent. of silica and alumina combined. If a more basic slag is attempted, trouble is caused by the cinder clogging the tuyeres. The iron made is a low phosphorous Bessemer, and for this reason commands a higher price than the usual run of Bessemer pig.

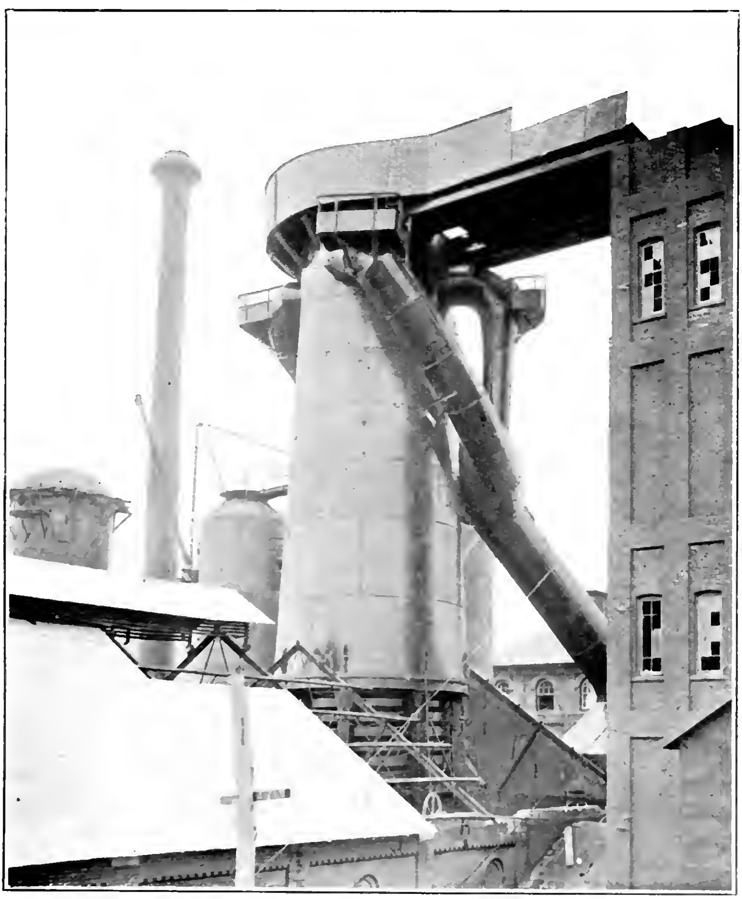
The ore charge consists of 85 to 95 per cent. of Chateaugay concentrates, the balance of the charge being mill cinder, and anywhere from 8 to 12 per cent. of the concentrates are blown out as flue dust. The charging bell is of the same type as that used in the Port Henry furnace, (i. e., a modification of the F. Firmstone pattern), the inside bell having a drop of 7 inches, but on account of the Chateaugay concentrates being so much finer than the Mineville material, this double section bell does not give as good results as are obtained in Port Henry.

The Superintendent, Mr. E. B. Tinney, to whom thanks are due for all information, stated that the furnace lining is about worn out, and he was confident that with re-lining better results would be secured.

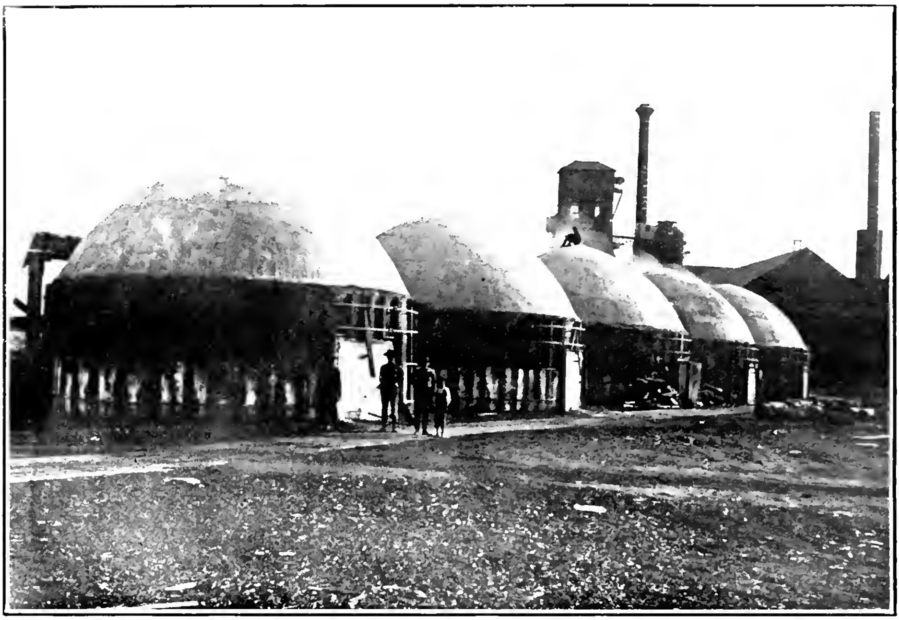
The chief trouble is due to the fact that the fine concentrates run ahead through the coke and accumulate as a blanket scaffold at some point near the top of the bosh. This has been proved many times, as for instance when the blast was off for changing a tuyere the red hot dust runs out through the tuyere breast in a regular stream. This blanket not only prevents the blast getting through, but also stops the column of material in the furnace descending, and brings all smelting operations to a standstill. The blast pressure will rise from normal 12 up to 20 lb. per square inch and if not relieved will finally stop the blowing engines. A furnace in this condition is said to "hang," and at Standish this "hanging" is almost continuous. In order to relieve this state of affairs the furnace is "slipped" at least once an hour, that is the blast is slackened for a moment, giving the stock in the furnace a chance to move, then the blanket or scaffold slips, and smelting goes on once more until another tightening up necessitates slipping again. Needless to say, this method of working the furnace is unsatisfactory, and under these conditions the Standish furnace does not produce more than 3,500 tons of iron per month. The company are however getting around the difficulty by installing a nodulizing kiln which is expected to nodulize 150 tons of concentrates per day, and then with the coarser ore mixture thus obtained the output will undoubtedly be increased.



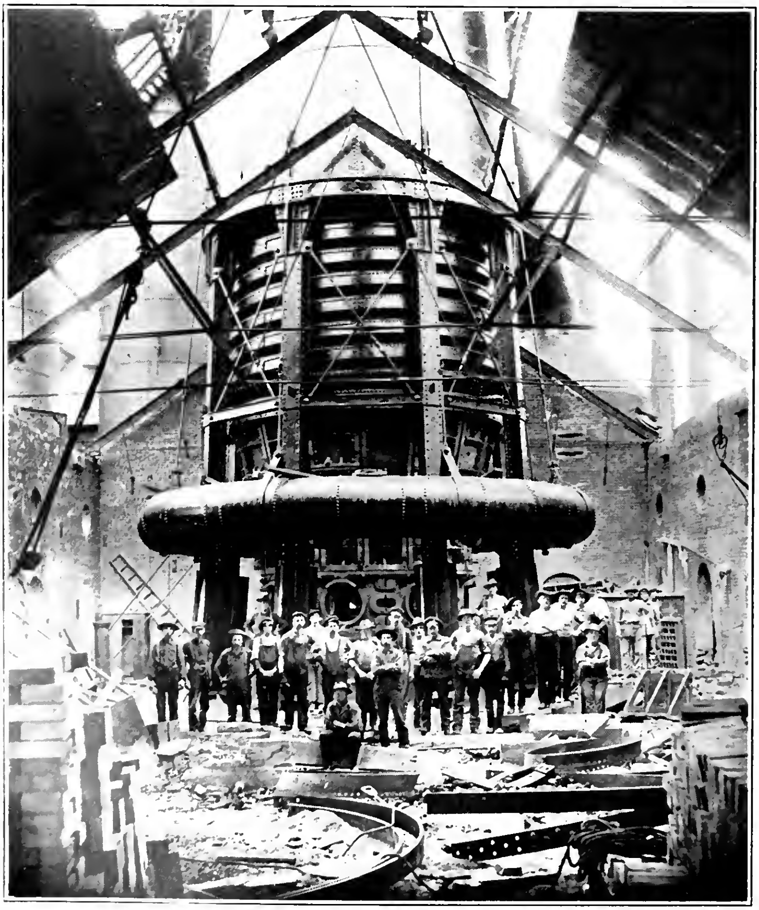
Blast furnace at Standish, N.Y., where concentrates from Lyon Mountain are used.



Blast furnaces at Standish, N.Y., showing arrangement of "downcomers."



Old charcoal kilns at Standish, N.Y., now dismantled.



Blast furnace at Standish, N.Y., showing cooling arrangement above the bosh.

Concentration and Nodulizing at Lebanon, Pa.

At Lebanon, Pa., the concentrating plant of The Pennsylvania Steel Company is successfully treating the low grade iron ores of the Cornwall district. After concentration, the fine ore is nodulized in four kilns of the same type as are used for clinkering cement.

The mines at Cornwall produced 18,000,000 tons of ore up to the end of 1904, and at present are yielding about 750,000 tons annually. This is worth noting, when it is considered that the ore is low grade and requires either roasting or concentration before it is fit for use in the blast furnace. The ore is a fine grade magnetite intimately mixed with talcose material low in phosphorus, but containing from 1.5 to 2.5 per cent. of sulphur. The sulphur exists partly as iron pyrites, and partly as chalcopyrite. The copper in the crude ore will average 0.44 per cent. This is partially recovered in the "copper mill" from the tailings after the magnetite has been removed. Some of the copper, however, remains with the iron ore and the nodulized product contains 0.20 per cent. of that metal.

Comparative analyses of crude ore, concentrates, nodules and tailings give the following figures:—

	Fe	SiO_2	Al_2O_3	Ca O	Mg O	S	P	Cu
	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.
Crude Ore	42.06	16.00	4.81	4.22	7.21	1.86	....	0.44
Concentrates	61.00	6.74	2.09	2.10	2.93	1.18	....	0.19
Nodules	60.00	8.92	2.29	2.39	2.98	0.03	0.01	0.20
Tailings	19.05	25.12	4.65	10.22	12.71	8.49	....	2.72

The mill was designed by the Allis Chalmers Company of Chicago and is substantially built of steel and wood on concrete foundations. The accompanying photographs of the exterior will give some idea of its size and construction. Several changes in the original design were made while the mill was being built, and the general plan of machinery and methods of separation have undergone modification during the development of the process. Dry concentration was the original scheme and different types of magnetic separators were used with varying success, until finally the Gröndal system of wet concentration was installed.

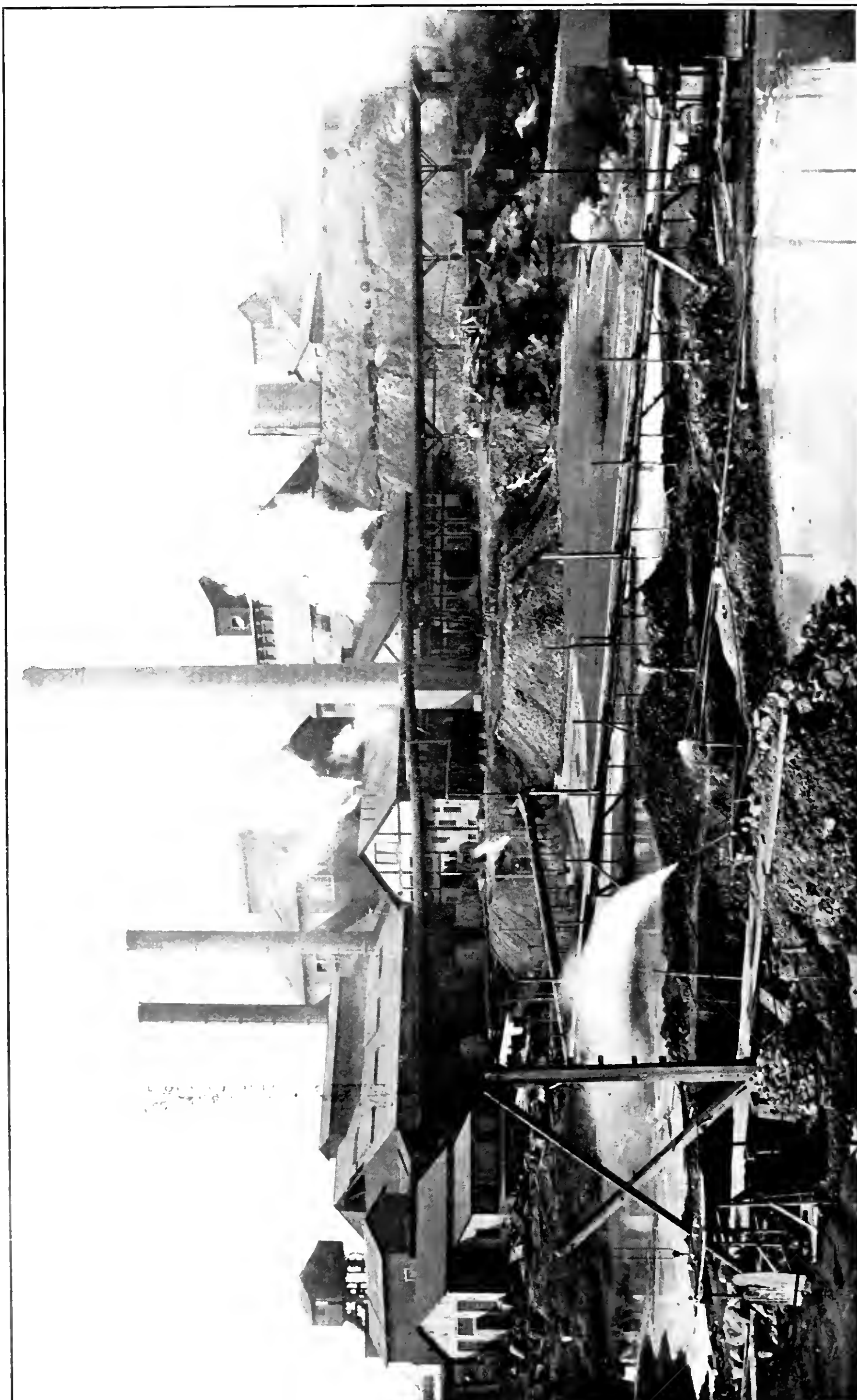
The Gröndal machines, which are the ones in use at present, have given the best results so far, and appear to have solved successfully the problem of concentrating the Cornwall ores.

The No. III. double Gröndal separator was the type first installed, and now the No. V. single drum Gröndal is being tried, with distinct success. The superintendent of the mill. Mr. B. E. McKechnie, to whom thanks are due for the information contained in this description, considers the No. V. Gröndal much superior to the No. III., both mechanically and also as regards expenses incidental upon operating and repairs—items that are well worth considering.

A diagramatic flow sheet of the mill is shown.[29] The path of the ore is indicated by arrow heads and each piece of machinery is numbered, so that by reference to the "Tree of the Process" the ore can be followed from its preliminary crushing through the mill to the nodulizing kilns. From 700 to 800 tons of crude ore are handled per day in two 12-hour shifts, and after separation will yield about 500 tons of concentrates, about 1½ tons of crude ore being necessary to produce one ton of concentrate. This proportion will vary, however, with the per cent. of iron in the crude ore.

The crude ore from the mine is delivered to the "upper mill" in drop bottom steel cars and is fed directly to a No. 6 Gates crusher, from which it gravitates down a chute to crushing rolls 15x40-inch running at a speed of 42 R.P.M. These rolls reduce

[29] See page 267.

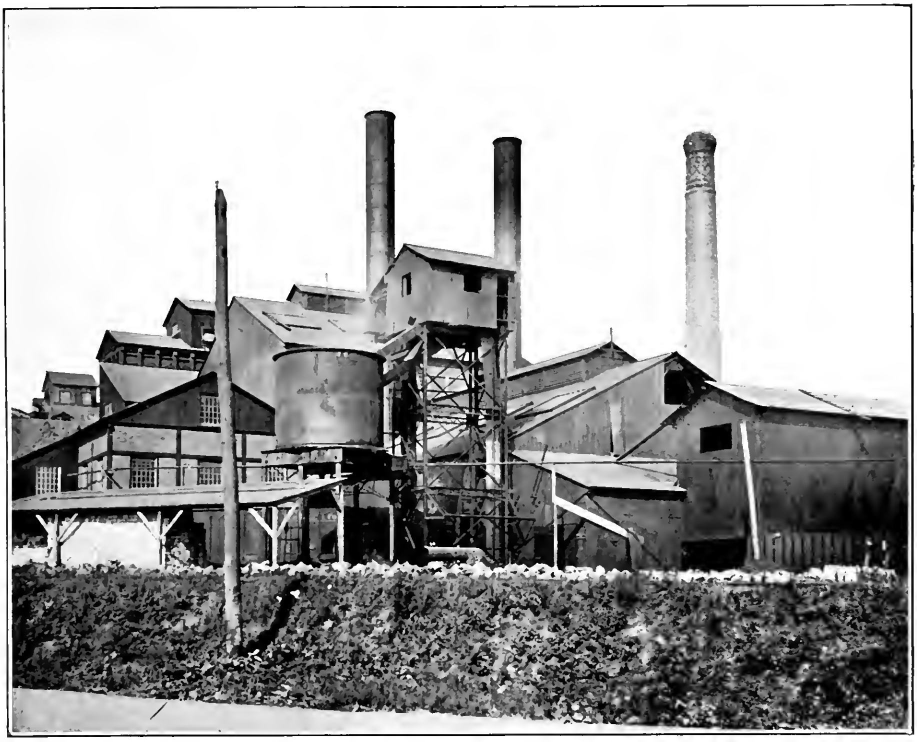


View of concentrating and nodulizing plant at Lebanon, Pa.; magnetic separators in upper portion and nodulizers in lower portion of mill.

the ore to ¾-inch size, and the crushed ore is then taken by a Robins belt conveyor to a large storage bin of 2,000 tons capacity. This upper mill, as it is called, is driven independently by a 75-h.p. Corliss simple engine, steam being supplied from the main boiler room.

Process of Concentration

From the storage bin the ore is fed to the "lower mill" over six ordinary feeders. Four of these feeders deliver to the "left side." The remaining two deliver to the "right side" of the mill; the two sides run independently of each other, and will be described separately.



Another view of Lebanon plant, showing bucket elevators and storage tank for hot nodules.

Left Side: The ore from the storage bin is fed over four ordinary drum feeders to four large wet ball mills of the central feed and discharge type, grinding to 1½-M.M. Each mill has an exterior 5-M.M. screen attached for removing chips, etc., etc. The pulp from these mills flows to 5 No. III. double Gröndal separators. The concentrates are laundered to the concentrate settling tanks, and the tailings go to a Frayer sand pump, where they are pumped to the "copper mill."

Right side: Two feeders deliver the ore from the bin to a pair of 5-M.M. trommels, that yield oversize to spring crushing rolls 15x40 inches, the undersize going to two 1½-M.M. trommels. The oversize from this second pair of trommels is sent to one double Gröndal coarse separator, while the undersize is delivered to a row of six double and one single Gröndal separators. The iron concentrates are laundered direct to the iron concentrates settling tanks, and the tailings go to the copper mill. The iron concentrates from the one coarse Gröndal separator are re-ground in a ball mill, and

then elevated to the six final separators mentioned above. Tailings from this coarse separator go to the copper mill. The oversize from the first pair of trommels, after passing the 15x40-inch rolls, is again screened in two 1½-M.M. trommels. The undersize is elevated to the six final magnetic separators, and the oversize is crushed in a second 15x40-inch rolls set very close, then screened again in a fourth set of trommels, the undersize being elevated to the final separators and the oversize going to the coarse Gröndal separator, thus completing the cycle.

All concentrates are laundered to three concrete settling tanks built immediately in front of the charging or cold end of the nodulizing plant. Each of these tanks is of 500 tons capacity, the bottoms being made of coarse stone filled in loosely to allow the water to drain off. Unfortunately there is so much water, and the concentrates are so fine, that this draining process is a slow one, so that concentrates are fed to the kilns containing 8 (?) per cent. of moisture. The three tanks are used in the following order: one being filled, one being drained and one being emptied. The superintendent is of the opinion that if he had double this tank capacity, i.e., if there were six tanks instead of three, much more water would drain off in the additional time gained, and the concentrates would then be fed to the nodulizers much drier, which is very desirable, for not only must the water be driven off in the kiln, but the dry concentrates can be fed with greater regularity, an important feature, because regularity of feed and heat in the kilns is essential, if best results are to be obtained.

The concentrates as fed to the nodulizing kilns run approximately 61 per cent. of iron with 1 per cent. of sulphur. The nodules from the kilns will average 58 to 60 per cent. of iron and contain only 0.03 per cent. of sulphur, proving that the kilns are good de-sulphurizers, also showing that part of the Fe_3O_4 in the concentrates is oxidized to Fe_2O_3 in the nodules. The sulphur in the concentrates could be reduced in the mill by closer separation, but as this sulphur can be eliminated in the kilns, nothing would be gained and considerable iron would be lost in the tailings.

The power for driving the lower mill is supplied by a 24x48-inch Corliss simple engine situated in the main engine room. Electrical energy for light and power is supplied by two 150-kilowatt Westinghouse generators connected directly with 16½x18-inch Buckeye engines. Exhaust steam is used for heating boiler feed water, and also for warming the mill, and the mill water in cold weather. Steam is generated in four 250-h.p. Babcock and Wilcox boilers, using blast furnace gas as fuel, piped about 2,500 feet from the blast furnaces. Coal is used as auxiliary fuel, but very little is needed.

Nodulizing Plant

At the lower end of the mill the four nodulizing kilns are installed. Three of these are 100 feet long by 7 feet in diameter, and fitted with four tires. The fourth is also one hundred feet long, but is eight feet in diameter, and this kiln is provided with only two tires. The three smaller kilns are lined throughout with 9-inch brick, while the larger one is only lined for 50 feet up from the hot end with 9-inch, the remainder being 6-inch brick. This method of lining is giving satisfaction and effects a saving in brick, with a corresponding lessening in the total amount of dead weight. It may be noted here that one of the smaller kilns has warped and during rotation lifts one tire from its rollers. This trouble is avoided in the two-tired kiln, for, no mater how much it may warp it must rest on its two supporting points. Also the two-tired kiln takes from 1 to 1½ less horsepower to rotate it, for the reason that there is less friction.

The concentrates are picked up out of the settling tanks by a clam-shell bucket operated from a 75-h.p. overhead electric crane, and are dumped directly into the feeders of the four kilns. Fuel is fed to the kiln at its lower end, and this fuel may be anything that is cheap and makes a hot fire. In Lebanon they use coal, coke-oven gas and coke-oven tar. Coal is preferred because the temperature can be held under better control, and the nodulized product is more uniform in size. In wet weather the coal grinders (three of these machines are used) cannot handle wet coal, and then coke-oven gas or

tar must be used, generally both together.[30] Whatever fuel is used, the highest temperature, 1,300 degrees to 1,400 degrees C., is maintained about 15 feet from the hot end. This range of heat is found to give the best results. Fuel consumption will approximate as follows: If coal is used, 180 lb. per ton of nodules will be required. Using coke-oven gas, 5,200 cubic feet are necessary per ton. While using coke-oven tar, 20 gallons will be required per ton of nodules produced. The coal used should contain over 25 per cent. of volatile matter and should be of such fineness that 90 per cent. will pass a 100-mesh screen. The superintendent's opinion was asked on the possibility of using powdered peat as fuel, it being pointed out that experiments had been tried for clinkering cement in an Ontario cement plant, and had been carried out with some success. His reply was to the effect that if a sufficient temperature could be maintained there was no reason why powdered peat would not answer, and as a much higher heat was

Coal grinders supplying powdered coal to the nodulizing kilns, Lebanon plant.

necessary for clinkering cement than that required for nodulizing iron ores, the suggestion of using peat fuel was well worth investigating.

Each kiln is rotated by a 30-h.p. Westinghouse variable speed motor. The average horsepower consumed per kiln, however, is not over 15, and the speed of rotation may be varied from 1 to 2 revolutions per minute. The red hot nodules of sintered ore drop from the lower end of the kiln to a chain bucket conveyor that runs under the four kilns and delivers the ore to a steel storage tank placed over a railroad track, from which it is shipped to the blast furnace. When all four kilns are running about 400 tons of nodules are made daily, the output both as regards quantity and quality depending upon the proper control of temperature and the regularity of the feed. The nodules are quite hard and porous. 80 per cent. of the product is larger than ¼-inch, and nothing is finer than 12-mesh, hence they make a very desirable material for smelting in the blast furnace.

[30] This trouble will be obviated by coal dryers, which are being installed.

Cleaning the Kilns

Inside the kilns and near the hot ends are formed heavy ring deposits of sintered ore, and every ten days or so each kiln must be taken off, cooled down, and cleaned out. Any repairs that are necesary are made at the same time. Repairs to the brick lining are very light; the original lining protected by the accumulated deposit lasts well, and although the kilns have been in operation over a year the only repairs needed are a few patches here and there. Two men employed one day a month, will make all lining repairs for one kiln. This heavy ring deposit has one good feature, in that it protects the brick lining. But when it grows so rapidly that it necessitates shutting down a kiln every ten days or so it becomes a serious drawback. It can be avoided to a certain extent, and the number of days a kiln can be run without needing cleaning may be increased by careful regularity in feeding the concentrates, and controlling the flame temperature. This strict regularity of feed cannot be obtained to any extent in Lebanon on account of the excessive moisture in the concentrates. Another feature that claims attention is the chain bucket conveyor that takes the hot nodules from the kilns to the outside storage tank. The heat from the red hot nodules plays havoc with this conveyor, causing the buckets to warp, hence breakdowns are frequent and repairs expensive. In designing a new plant the obvious remedy would be to do away with the conveyor altogether, and to place the storage tank on a lower level than the kilns, allowing the hot nodules to gravitate down to it through iron chutes. Or a skip hoist might possibly prove the better solution of this difficulty.

A visit was paid to the blast furnace plant of the company, with the idea of learning how the nodulized product of the concentrating mill behaved in the process of smelting. Mr. R. H. Lee, superintendent of the furnaces, to whom the writer is indebted for much information, was most enthusiastic on the subject of nodulized small ores, stating that a considerable fuel economy was secured by their use, and that the furnaces when burdened with a liberal percentage of this material, ran more uniformly and with less trouble than when using straight roasted ore. Interesting data was furnished by Mr. Lee fully establishing his contentions, but the writer in deference to the wishes of The Pennsylvania Steel Company is unable to present this information for publication.

Tree of the Process

Crushing Mill:—

1. Cars from mine deliver ore to (2)
2. Gates Crusher No. 6 to (3)
3. Coarse rolls 15 x 40 inches and 42 R.P.M. to ¾ inch to (4)
4. Robin's Belt conveyor to (5)

Concentrating Mill:—

5. Bin 2000 tons capacity to (6) and (9)

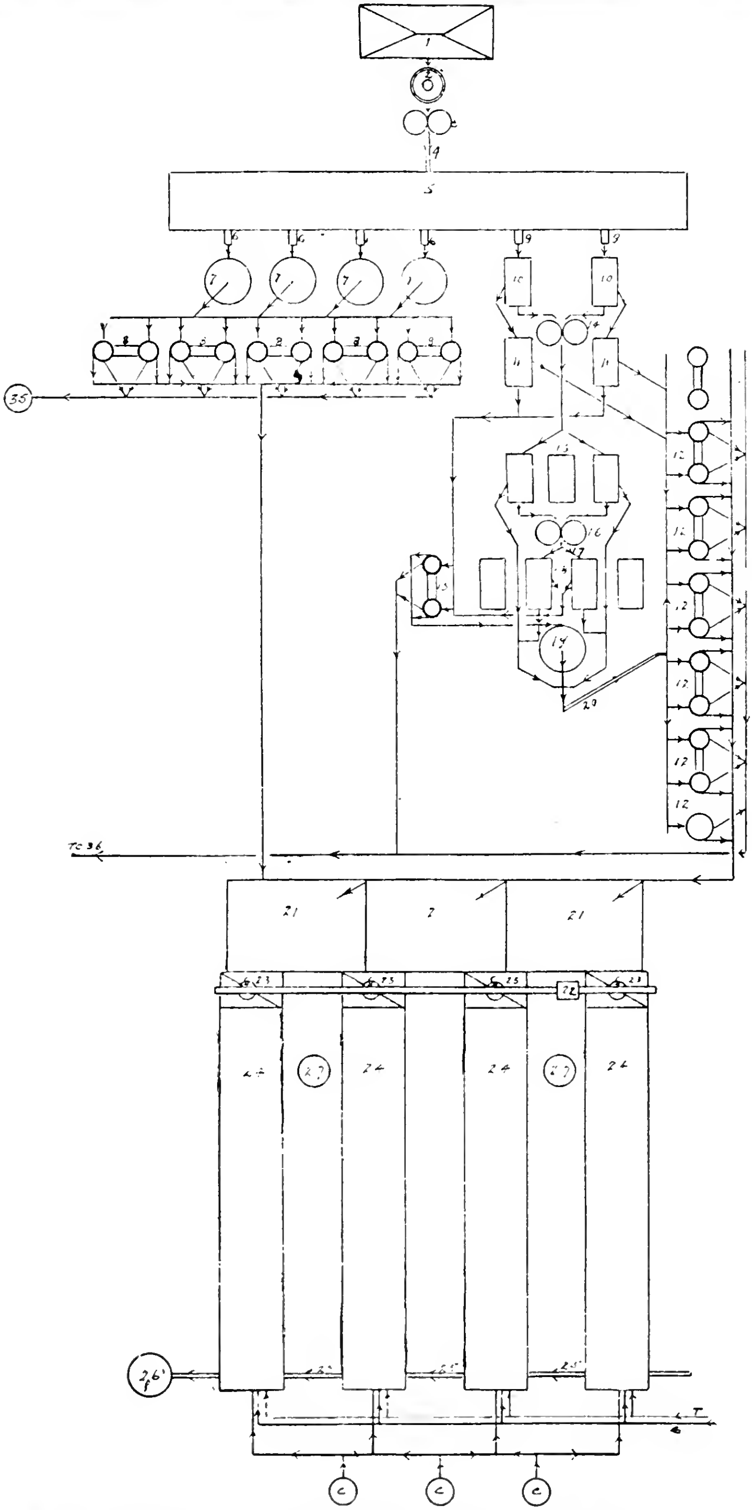
The Mill has two sides:

Left Side:—

6. 4 Feeders to 7
7. 4 Ball Mills to 1½ M.M. to (8) and 5 M.M. for chips
8. 5 Double Gröndal Separators yield non-magnetic to (35) and magnetic to (21)

Right Side:—

9. 2 Feeders to (10)
10. 2 Trommels 5-M.M. yields oversize to (14) undersize to (11)
11. 2 Trommels 1½-M.M. yields oversize to (13) undersize to (12)
12. 6 Double Gröndal Separators
1 Single Gröndal Separator } 6 working. Magnetic to (21), non-magnetic to (35)
13. 1 Double Gröndal coarse Separator yields non-magnetic to (36) and magnetic to (19)



Diagramatic sketch of the separating and nodulizing process at Lebanon, Pa.

14. No. 1, Spring Rolls 15 x 40 inches, to (15)
15. 3 Trommels $1\frac{1}{2}$-M.M. (2 working) yields oversize to (16), undersize to (20)
16. No. 2, Rolls 15 x 40 inches set close to (17)
17. Elevator to (18)
18. 4 Trommels $1\frac{1}{2}$-M.M. (2 working) yields oversize to (13) and undersize to (20)
19. Ball Mill $1\frac{1}{2}$-M.M. to (20)
20. Elevator to (12)
21. Iron Concentrate bins to (22)

Nodulizing Plant:—

22. Electric overhead crane 75 h.p. to (23)
23. 4 Feeders to (24)
24. 4 Nodulizing Kilns to (25)
25. Chain Bucket Conveyor to (26)
26. Storage tank for hot nodules.
27. 2 Draft Stacks for kilns

C.C.C. 3 Coal Grinders to 100-mesh feeding to (24)
G. Gas pipe line from Coke oven plant to (24)
T. Tar delivered from tank cars to storage tank to (24)
35. Frayer sand pump to (36)
36. Settling tank for copper mill.

The labor required in operating the concentrating and nodulizing plant at Lebanon is as follows:

Upper Mill; 4 men unloading ore, 1 engineer and 1 helper; total, 6 men per 12-hour shift: per 24 hours, 12 men.

Lower Mill; 1 man at storage bin, 1 man at ball mill feeders, 1 man at trommel feeders, 1 man at ball mills, 1 man at separators, 1 oiler, 1 foreman; total, 7 men per 12-hour shift; per 24 hours, 14 men.

Nodulizing kilns; 1 man at crane, 1 man at feeders, 1 oiler, 1 man at burners, 1 laborer; total, 5 men per 12-hour shift; per 24 hours, 10 men.

Engine Room and Boilers; 1 engineer and 1 helper, 2 firemen, 1 coal wheeler; total, 5 men per 12-hour shift; per 24 hours, 10 men.

Grand total, 23 men per 12-hour shift; per 24 hours, 46 men.

General; 1 master mechanic, 1 electrician, 2 machinists, 8 machinist's helpers, 1 boss carpenter, 2 carpenter helpers; total, 15 men per 10-hour shift.

Labor; 1 boss and 9 men; total, 10 men per 10-hour shift.

The power necessary to run the machinery is apportioned thus:

	Horsepower.	
Upper Mill:		
1 No. 6 Gates Crusher	50	
1 40 x 15-inch Rolls	10	
1 Belt Conveyor and Lights	15	75
Lower Mill:		
2 40 x 15-inch Rolls	25	
5 Ball Mills	125	
2 Elevators	5	
16 Screens	10	
1 6-inch Tailings pump	25	
12 Magnetic Separators	50	
Water pumps	100	
Lights	10	350

Nodulizing Kilns:		
1 Crane	75	
4 Kilns	60	
3 Coal Grinders	60	
4 kiln feeders	5	
1 Conveyor	5	
Lights	5	210
Copper Mill:		
7 Tables and 1 jig	3	
1 Ball Mill	10	
Pumps	2	15
Total horse power required		650

Concentration Tests with Ontario Magnetites

In order to show that low grade Ontario magnetites are amenable to concentration by means of the electro-magnet, and with the view of ascertaining if possible the per cent. of separation efficiency that might be expected in actual commercial operation. samples of ore were obtained from various localities in the Province and submitted to preliminary testing.

In most cases the samples were secured by the writer in person, from old ore piles adjacent to the mine workings, and as far as the time at his disposal permitted, samples were taken as representative of the average of the piles of ore. The sample from the township of Hutton was supplied by Mr. N. L. Leach, Manager of Moose Mountain Limited, and the Temagami jaspilyte sample was obtained from Mr. T. B. Caldwell of Lanark, to whom thanks are due for his kindness and courtesy in supplying the writer with information on the iron industry in general.

The separating tests were carried out in the mining laboratory of the Kingston School of Mines, and as the only magnetic concentrator the laboratory contained was an old Wetherill bi-polar machine, it was decided to build a single drum Ball and Norton separator. The design and construction of this machine was carried out under the supervision of L. W. Gill, Professor of Electrical Engineering from details supplied by Stafford Kirkpatrick, Professor of Metallurgy, and the writer.

The exciting field of this machine consists of 12 stationary electro-magnets carried by a cast-iron spider and enclosed in a brass drum 14 inches across the face and 18 inches in diameter, the drum being protected by a thin rubber sleeve. The electro-magnets have a capacity of 10 amperes at 110 volts and are arranged in a series of alternate polarity, the position of the field being altered at will by means of an outside arm attached to the spindle carrying the magnets. The drum is made water tight and may be used in either of two box wells placed side by side for dry or wet concentration, an overhead travelling trolley being provided to lift the drum from one box to the other. Power is supplied by a ¾-h.p. electric motor.

All of the samples tested were small, ranging from 5 up to 25 pounds in weight, hence it was impossible to make anything but preliminary tests, and the results shown in the accompanying table should be regarded as indications only of the possibilities of actual work on a large scale. As the samples were small, the crushed ore was not sized by screens before separation, and this important detail had therefore to be omitted. A complete test on each sample of ore would consist of crushing, say a ton lot down to about ¼-inch, followed by screening the crushed material to a half dozen different sizes, and concentrating each size separately. In this way an accurate idea would be gained of the exact size to which the ore should be crushed in order to afford the most efficient

separation. If it was found necessary to pulverize the ore finer than 20-mesh, in order to give a concentrate containing over 60 per cent. in iron, with not more than 10 per cent. of iron lost in the tailings, the ordinary dry method of separation would probably not prove as efficient as the wet process, because of the difficulty experienced in keeping the concentrates free of gangue dust and preventing fine particles of magnetite being carried into the tailings. Unfortunately both wet and dry methods could not be carried out in making the present tests, as the samples were too small to be divided. This is regrettable as it prevented comparisons being made as regards the efficiency of each process on any given ore.

The crude ore samples were analyzed quantitatively for magnetite (Fe_3O_4), insoluble matter, sulphur and phosphorus; qualitative tests were also made for titanium, but only traces of that element were found in certain cases. The concentrates were analyzed for magnetite, insoluble matter, and sulphur in those instances where the original ore was high in sulphur. Tailings were run for soluble iron only, the percentages of magnetite being calculated therefrom. This is of course inaccurate, as the tailings contained iron in the form of iron pyrites and ferro-magnesian minerals to some extent, hence all percentages of magnetite in the tailings may be considered high, especially in those cases where the crude ore was high in sulphur. All analyses were made by A. G. Burrows, Provincial Assayer.

The results of the different tests are tabulated in the accompanying form showing in each case the treatment of crude ore, concentrates, tailings, and the efficiency of the operation. In order to make clear the interpretation of this table, the following made by A. G. Burrows, Provincial Assayer.

A Sample from Robertsvillle Mine

Take the case of Robertsville Lizzie mine. This ore on analysis showed 52.58 per cent. of magnetite (38.17 per cent. iron) 35.3 per cent of insoluble matter, 0.38 per cent of sulphur and 0.025 per cent of phosphorus. The sample was crushed so that it would all pass a 5-mesh screen, and then fed through the separator; the drum running at 100 R.P.M. and the magnets excited by a current of 4 amperes at 110 volts. The tailings from this first operation were then re-passed twice, the drum running at 100 R.P.M., and the magnets excited by a current of 5 amperes, the final tailings being considered as waste. The concentrates were then re-passed twice, the drum running at 90 R.P.M., the exciting current being 6 amperes, the heads from the second pass were called final concentrates, and the tails united with the preceding waste to form the final tailings. The final concentrates proved on analysis to contain 94.03 per cent. of magnetite (68.11 per cent. iron), 3.80 per cent. of insoluble matter, and 0.03 per cent. of sulphur. The final tailings analyzed 2.93 per cent. of iron corresponding to 4.05 per cent. of magnetite. The efficiency of the operation calculated by the equations given on a preceding page showed that 96.66 per cent. of the original magnetite in the crude ore was saved in the concentrate, and that 3.44 per cent. of the original magnetite was lost in the tailings; also that 1.85 units of crude ore were required to make one unit of concentrate.

The following analysis will make this more clear:

Magnetite in crude ore		= 52.58	per cent.
"	" Concentrates	91.03	"
"	" Tailings	4.05	"

Then by equation (1)

$$\frac{91.03-4.05}{52.58-4.05} = 1.85 \text{ units of crude ore required per unit of concentrate.}$$

Therefore

$$\frac{10 \text{ units of crude ore}}{1.85} = 5.405 \text{ units of concentrate obtained from 10 crude units.}$$

But 10 units of crude ore contain 5.258 units of pure magnetite (by analysis). Hence the distribution is as follows:—

			p. c.	Units.
10 units crude ore	5.405 units of concentrate 54.05 per cent. =	Magnetite	94.03 =	5.0823
		Gangue	5.97 =	0.3227
				5.405
	4.595 of Tailings. 45.95 per cent. =	Magnetite	4.05 =	0.1861
		Gangue	95.95 =	4.4089
				4.595
			Total......	10.000

The efficiency of the operation will be $\frac{\text{5.0823 units of magnetite in Concentrate} \times 100}{\text{5.258 units of magnetite in crude.}}$ = 96.66 per cent. of the magnetite in crude ore saved in concentration

and, $\frac{\text{0.1861 units of magnetite in tailings} \times 100}{\text{5.258 units of magnetite in crude}}$ = 3.53 per cent. of the magnetite in crude ore lost in the tailings.

It will be noted here that 96.66+3.53=100.19. This is explained by the fact that the percentage of magnetite in the tailings was calculated direct from the soluble iron therein, no allowance being made for the iron contained in the pyrites, hence the per cent. of magnetite in the tailings as given was slightly above the actual amount.

It may be objected that this method of re-concentrating tails and heads is not comparable with actual practice. This is partly true, as the concentrates are seldom passed through the machine again. The tailings, however, are always re-crushed and re-separated until their iron content fails below the economical point of recovery. Time did not permit of this re-crushing of the tails, hence the above method was followed as a substitute, and although this method may not be admissable in actual practice, the results afforded can be taken as indicative of what might be expected from a commercial process.

Silicious Magnetite from Hutton

The sample of silicious magnetite from Hutton township was of a very fine crystalline structure and required pulverizing to 60-mesh in order to separate the constituent minerals. This was proved in a preliminary test as follows; thirty-eight and a half ounces of the crude ore were crushed so that 24.85 per cent. passed a 40-mesh screen, 20.90 per cent. passed a 60-mesh screen and 54.25 per cent. passed an 80-mesh screen. The different sizes were then concentrated separately with the following results:—

	Crude ore.		Concentrates.		Tailings.	
Pass Screen.	Ounces of ore.	Per cent. of ore.	Per cent. of concentrates.	Per cent. of iron in concentrates.	Per cent. of tailings.	Per cent. of iron in tailings.
80 mesh	20.75	54.25	47.20	60.90	58.00	11.58
60 "	8.00	20.90	24.55	49.56	19.00	13.88
40 "	9.5	24.85	28.25	47.01	23.00	17.43
	38.25	100.00	100.00	....	100.00	....

The above was accepted as proof that the ore required grinding finer than 40-mesh to give efficient separation results, and therefore for the final test the sample was pulverized so that it would all pass a 60-mesh screen. The results of this test shown in the accompanying table, indicates that this ore is not easily concentrated dry. The amount of dust carried into the concentrates, shown by the percentage of insoluble

matter in the heads, and the per cent. of iron lost in the tailings combine to give a low separation efficiency.

The jaspilyte ore from Temagami composed of alternate bands of fine grained magnetite and jasper did not require grinding finer than 20-mesh to give a higher efficiency result than the Hutton ore, because only 1.29 units of crude ore containing 66.26 per cent. of magnetite were required to make one unit of concentrate containing 78.02 per cent. of magnetite. However, the results of this test are not satisfactory from the standpoint of dry separation, and it is probable that for commercial work the wet method would have to be employed.

All of the remaining samples[31] were crushed to 5-mesh only, as it was expected that fair results would be obtained without finer grinding. This assumption proved to be correct in the majority of cases, and concentrates were obtained averaging well over 60 per cent. in iron and low in insoluble matter. The percentage of sulphur in certain samples was not reduced in the concentrate to as low a point as had been hoped for, but as this element can be eliminated in the subsequent nodulizing process, its presence is not hurtful unless an attempt is made to smelt the concentrates without agglutinizing.

It is probable that the concentrate from all of the above ores would require either nodulizing or briquetting before being used for smelting. This could doubtless be definitely ascertained by making a sieve test to determine the relative percentages of different sized material which the concentrate contained, and if time had permitted this would have been carried out in each case.

The writer wishes to thank Mr. G. J. McKay, Demonstrator in the School of Mines, Mining Laboratory, for assistance rendered during the time the separation tests were being made.

Cost of Grondal Plant, 1,000 Tons Per Day

Messrs. Fitzgerald and Bennie, Niagara Falls, N.Y., Canadian agents for the Gröndal Process, have furnished data as to the cost of erection and operation of the Gröndal system of concentrating and briquetting, the plant to treat 1,000 tons of crude ore per 24 hours.

In presenting this estimate it should be explained that as there is no plant of similar character operating in this country, accurate data pertaining to costs of operation were difficult to obtain, and therefore the several items are subject to variations according to local conditions. Against this it should be pointed out that in every case the European plants which have installed the Gröndal apparatus are deriving a good commercial profit, so that it may only remain to choose wisely the location in Ontario to obtain similar success.

The cost of the crude ore is taken at $1.25 per net ton delivered at the plant. This no doubt could be reduced in many cases to less than $1.00, but it was thought advisable to insert the higher figure as part of the crude ore required may possibly be transported some distance from outlying mines. No provision is made for an extensive storage yard and automatic ore handling machinery, but if the plant were so located that shipments from the mines were intermittent during the winter months, a large stock of crude ore would be necessary, and for its economical handling a modern ore bridge equipped with grab buckets is essential.

It is assumed that 1,000 tons of crude ore averaging 40 per cent. iron are delivered to the mill every 24 hours at $1.25 per ton; that two tons of crude ore are required to make one ton of concentrates, allowing for a loss of 12 per cent. in the tailings; and that 500 tons of concentrates are produced, averaging 68 per cent. of iron, which will make about 520 tons of briquettes containing 65 per cent. of iron.

[31] See page 273 for full table of results.

Results of Concentration Tests on some Ontario Magnetites

Sample	Crude Ore.									Concentrates.								Tailings.					Efficiency of Separation.		
	Magnetite (Fe_3O_4), per cent.	Iron (Fe), per cent	Insoluble matter, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Crushed to mesh.	Passed through separator.	Exciting current, amperes.	Speed of Drum, R. P. M.	Re-passed through separator.	Exciting current, amperes.	Speed of Drum, R. P. M.	Magnetite (Fe_3O_4), per cent.	Iron (Fe), per cent.	Insoluble matter, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Re-passed through separator.	Exciting current, amperes.	Speed of Drum, R. P. M.	Magnetite (Fe_3O_4), per cent.	Iron (Fe), per cent.	Magnetite in crude saved in the concentrate, per cent.	Magnetite in crude lost in the tailings, per cent.	Units of crude ore required to make one unit of concentrate.
Hutton, Silicious	48.95	35.46	50.66	0.02	0.064	60	once.	4	100	once.	6	155	78.43	56.80	21.64	......	....	once.	5	100	23.61	17.10	83.71	16.29	2.12
Temagami, Jaspilyte	66.28	48.00	31.33	0.014	......	20	"	5	100	"	6	155	78.02	56.51	20.30	......	....	twice.	4	100	26.90	19.49	90.55	9.45	1.29
Blairton, Cull Ore	58.90	42.65	22.28	0.95	0.028	5	"	4	100	twice.	5½	125	81.61	59.11	11.77	0.175	....	once.	5	100	30.52	22.10	76.99	23.01	1.80
Belmont, Cull Ore	77.35	56.02	17.10	0.36	0.02	5	"	4	100	"	6	120	92.53	67.01	5.70	0.58	....	twice.	5	100	19.22	13.92	91.92	5.08	1.26
Clarendon No. 1	79.05	57.25	8.67	0.03	0.01	5	"	4	100	not re-passed	....	....	86.28	62.49	5.23	......	....	thrice.	6	120	19.32	13.99	97.45	2.55	1.12
Robertsville No. 1	87.15	63.11	10.82	trace.	0.003	5	"	4	100	"	....	....	95.65	71.27	3.42	......	....	twice.	5	100	7.33	5.31	99.24	0.76	1.106
" Lizzie Mine	52.58	38.17	30.30	0.38	0.025	5	"	4	100	twice.	6	90	94.03	68.11	3.80	0.03	....	"	5	100	4.05	2.93	96.66	3.44	1.85
" Mary Mine	35.96	26.04	55.86	trace.	0.14	5	"	3½	100	once.	5½	100	78.85	57.11	18.72	......	....	"	5½	100	8.74	6.33	85.32	14.68	2.57
Glendower No. 1	87.74	63.54	8.26	0.01	0.01	5	"	4	100	not re-passed	....	....	94.30	68.30	2.88	......	....	thrice.	6	90	12.01	8.70	99.50	0.50	1.08
" Cull Ore	77.63	56.21	12.57	0.86	0.008	5	"	4	100	"	....	....	88.10	63.81	6.85	0.36	....	"	6	90	12.18	8.82	97.83	2.17	1.16
Wilbur No. 1	93.53	67.73	3.25	0.14	0.005	5	"	4	100	once.	3½	100	94.78	68.65	2.01	......	....	......	....	....	......	......	......	......	......
" shipping average	76.63	55.49	3.45	0.01	0.022	5	"	4	100	not re-passed	....	....	86.31	62.51	4.85	......	....	twice.	5½	90	22.06	15.98	95.15	4.85	1.17
Calabogie No. 4	81.28	58.86	6.53	0.45	0.18	5	"	4	100	"	....	....	90.86	65.81	3.75	0.135	...	thrice.	5½	100	27.04	19.58	94.73	5.27	1.18
" Caldwell East Pit	79.88	57.85	10.23	0.03	0.17	5	"	4	100	"	....	....	89.98	64.17	5.02	......	....	"	5½	120	8.12	5.88	98.82	1.18	1.14
" " West Pit	72.27	52.34	6.62	1.16	0.37	5	"	4	100	"	....	....	86.72	62.81	4.76	0.33	....	"	6	100	18.39	13.32	94.48	5.52	1.27
" Martell Mine	69.59	50.37	26.31	0.103	0.05	5	"	4	100	"	....	....	83.03	60.34	14.05	......	....	twice.	6	155	18.19	13.17	94.86	5.14	1.26
" Bluff Point	79.30	57.43	9.74	0.19	0.016	5	"	4	100	twice.	6½	120	90.03	65.21	4.04	0.108	....	thrice.	6	100	12.59	9.12	97.88	2.12	1.16
Bessemer No. 1	69.29	50.18	22.81	0.177	0.009	5	"	4	100	not re-passed	....	....	90.17	65.30	7.10	0.048	....	"	6	120	13.73	9.91	93.62	6.28	1.39
" No. 3, Pit Cull Ore	13.43	31.35	37.33	0.84	0.021	5	"	4	100	"	....	....	87.55	63.41	9.30	0.45	....	twice.	5½	100	11.18	8.10	85.42	14.58	2.36
" No. 4, Pit Cull Ore	46.30	33.53	39.16	0.96	0.01	5	"	4	100	"	....	....	82.23	59.56	13.64	0.73	....	"	5½	120	14.14	10.24	83.77	16.23	2.12

NOTE.—All the Analyses were made by A. G. Burrows, Provincial Assayer.

Cost of Concentrating Plant

1 large Blake or Gates Crusher	$ 4,000
1 smaller " " " breaking to less than 1 inch size	4,000
12 Gröndal ball mills, large type, ($1,800.)	21,600
12 Gröndal magnetic Separators, ($750.)	9,000
12 slime boxes and de-waterizers, ($500.)	6,000
Transmissions, elevators, feeders, water launders, piping, etc	10,000
Foundations and buildings	20,500
Installation of machinery	5,000
Ore storage yard, tracks, trestles, etc	5,000
Total	$85,100

If it is desired to produce some concentrates of very high iron content, say 70 per cent., re-grinding would probably be necessary, in which case the installation of tube mills with an equipment of additional separators for reconcentrating would be required. Probably one, and not more than two such units would be necessary, which would increase the cost of installation by $5,000.00.

Cost of Briquetting Plant

6 Twin Briquetting furnaces complete	$ 72,000
360 Furnace cars	57,000
12 Briquetting presses	15,000
Gas producers and piping	15,000
Foundations and buildings	15,000
Sundries, contingencies, etc	12,000
Total	$186,000

Power Plant

It is assumed that a 500-h.p. steam and electrical installation, for both concentrating and briquetting plants, including pumping machinery for supplying the mill with water, will be sufficient. This plant would probably cost $25,000 complete.

Total Cost of Complete Plant

Concentrating mill	$ 85,100
Tube-mills and re-concentrators (if desired)	5,000
Briquetting plant	186,000
Power plant	25,000
Total	$301,100

For a plant handling 1,000 tons of crude ore daily it is obvious that considerable working capital will be tied up in concentrates and briquettes, and an additional amount in current accounts, so that $350,000 would not be too much for the total capital required.

Operating Expenses

Power Plant, labor required

Engineers	1 man per shift	2 men per 24 hours
Engineer's helpers	1 man per shift	2 men per 24 hours
Firemen	3 men per shift	6 men per 24 hours
Coal wheelers	2 men per shift	4 men per 24 hours
Total	7 men per shift	14 men per 24 hours

2 Engineers at $2.75	$ 5.50
2 Helpers at $2.25	4.50
6 Firemen at $2.00	12.00
4 Coal wheelers at $1.50	6.00
	$28.00 total labor bill for 24 hours.

It is assumed that the concentrating and briquetting mills are each charged with one-half of the above costs, that is $14.00.

Concentrating Mill, labor required:

Master mechanic	1 man	1 man per 24 hours
Dumping and weighing crude ore	4 men per shift	8 men per 24 hours
Crushers	3 men per shift	6 men per 24 hours
Ball mills	2 men per shift	4 men per 24 hours
Separators	2 men per shift	4 men per 24 hours
De-waterizers	2 men per shift	4 men per 24 hours
Oiler	1 man per shirt	2 men per 24 hours
Electrician	1 man	1 man per 24 hours
Weighing and loading concentrates	3 men per shift	6 men per 24 hours
Foremen	1 man per shift	2 men per 24 hours
Totals	20 men per shift	38 men per 24 hours

1 master mechanic at $4.00	$ 4.00
34 men per 24 hours at $1.75	59.50
1 electrician at $2.50	2.50
1 night foreman at $3.00	3.00
1 day foreman at $3.50	3.50
	$72.50 total labor bill per 24 hours.

Cost per ton Concentrates:

Concentrating mill labor	$72.50
Power plant, labor	14.00
	$86.50 labor bill per 500 tons of concentrates produced = $0.173 per ton.

Labor	$0.173
Power	0.10
Repairs	0.10
Oil and miscellaneous	0.127
	$ 0.50 cost per ton of concentrates.

Briquetting Department, labor required:

Feeding presses	6 men per shift	12 men per 24 hours
Attending presses and loading cars	12 men per shift	24 men per 24 hours
Charging furnaces	6 men per shift	12 men per 24 hours
Discharging furnaces	6 men per shift	12 men per 24 hours
Gas producers	2 men per shift	4 men per 24 hours
Foreman	1 man per shift	2 men per 24 hours
Total	33 men per shift	66 men per 24 hours

64 men at $1.75	$112.00
1 foreman at $3.00	3.00
1 foreman at $3.50	3.50
	$118.50 total labor bill per 24 hours.

Cost per ton of briquettes:

Briquetting plant, labor	$118.50
Power plant, labor	14.00
	$132.50 labor bill per 520 tons of briquettes produced = $0.254 per ton.

If producer gas is used as fuel, about 35 tons of coal will be required per 24 hours. Assume value of coal to be $3.50 per ton = $122.50 per day or $0.233 per ton of briquettes.

Labor	$0.254
Fuel	0.223
Power	0.030
Repairs	0.10
Oil and miscellaneous	0.043
	$0.65 cost per ton of briquettes.

Total cost of one ton of briquettes:

Two tons of crude ore at $1.25 per ton delivered	$2.50
Concentrating	50
Briquetting	65
	$3.65
Depreciation and amortization at 15 per cent. on $350,000	35
Total cost of production	$4.00

Market Prices of Concentrates and Briquettes

During the past year the following prices have been paid for concentrates containing 68 per cent. of iron: for home consumption in Sweden about $3.65 per ton on cars at concentrators; for export containing 65 per cent. of iron and about 10 per cent. of water $4.25 per ton, at port of export

For briquettes containing 65 per cent. iron, sales have been made at $5.45 per ton f.o.b. port of export. Germany has contracted for about 10,000 tons this year at $5.25 at port of export. Purple ore briquettes from Helsingborg bring about $6.00 per ton Stockton. Pyrites residues briquettes from South Wales command from $5.50 to $6.35 delivered, according to cost of transport.

In comparison with the best of the Old Range Lake Superior Bessemer ores, which this year are quoted at $5.00 per ton at lower lake ports, for 55 per cent., iron content or 9.09 cents per unit, the briquettes should have no trouble in commanding and holding an equal price per unit or $6.00 per ton, with the probability of exceeding this price, as the supply of lake ores diminishes.

The return on investment may be summed up approximately as follows:—

Cost of producing briquettes at the works	$4.00
Freight, by rail and boat to lower lake ports	1.25
Royalty per ton	.10
	$5.35 per net ton
Selling price	$6.00 per net ton
Profit	0.65 per net ton
Annual tonnage	150,000 net tons
Annual profit 150,000 tons at 65 cents	$97,500
Return on investment of $350,000	27.8 per cent.

It may be of interest to state here what has already been pointed out in another part of this report, that in 1907 Ontario furnaces smelted 508,883 tons of iron ore. Of this amount 388,727 tons or 76.3 per cent. were imported from the United States, and 120.156 tons or 23.6 per cent. were mined within the Province. There should be no difficulty in disposing of 150,000 tons of briquetted ores in Ontario alone, and in fact, if such an industry were established, there is every probability that the demand for the briquettes would exceed the supply.

Cost of Dry Magnetic Concentrating Plant, 1,000 Tons per Day.

The following estimate has been prepared by Allis-Chalmers-Bullock, Limited, to whom the writer wishes to make thankful acknowledgment for the assistance rendered. In presenting this estimate, it is regretted that an insufficiency of data makes it impossible to afford a definite comparison with the Gröndal or wet system of concentration. However if it is studied in conjunction with the description of the dry concentrating plants given in another part of this report, especially the Lyon Mountain mill, some idea will be gained of the relative merits of the two systems under consideration.

It may be advantageous to emphasize here one or two of the main points of difference between dry and wet magnetic concentration. In the first place, dry concentration is applicable only when the crude ore does not require fine grinding to free the particles of magnetite from adhering particles of gangue, and as the process is operated dry the ore must be thoroughly dried before going to the magnetic separating machines. The wet process is specially applicable where fine grinding is necessary, and because the grinding and separating of the ore is effected with the use of a considerable amount of water, no preliminary drying is required; although the resulting concentrates must be partially de-waterized before being briquetted or nodulized. The process of dry separation, requiring no water, does away with the expense of installing pumping machinery, piping, launders, etc., and the operation of the mill is simplified, especially during the winter months, when the danger of freezing would necessitate heating the mill water. Also, the concentrator being dry obviates the use of de-waterizing apparatus before nodulizing.

The process of nodulizing claims some attention, and it should be stated here that this system of agglomerating fine ores has met with considerable success at several American plants. The essential points of difference between the nodulizing kiln and the Gröndal briquetting furnace are that the former has a greater tonnage output per unit, but requires more fuel per ton to operate than the latter. The cost of installing a battery of kilns would be considerably less than the cost of installing briquetting furnaces for any given output, and it is probable that the operating expenses per ton of product would be lower for the kilns, notwithstanding the fact that the briquetting furnace is more economical of fuel. It has been stated that the nodulizing kilns are not good de-sulphurizers, but a glance at the analyses of concentrates and nodules made at the Lebanon plant of The Pennsylvania Steel Company will demonstrate that the kilns are very efficient in this respect, reducing the sulphur from 1 per cent. in the concentrates to 0.03 per cent. in the nodules. The nodules are hard and porous, not so porous as the Gröndal briquette, but they have sufficient porosity to greatly promote their rapid reduction in the blast furnace. And the smaller size of the nodule compared with the briquette admits of more rapid reduction by the furnace gases, in the same way as a small lump of sugar is dissolved in water more quickly than a large lump. If there is one argument against the nodules, it is that they are not sized; they are of any and all sizes from pieces as large as a hen's egg down to particles not larger than a grain of wheat. This means that when charged in the blast furnace the smaller particles fill up the interstices between the larger lumps and form a layer less easily penetrable by the ascending gases than a charge of briquettes under similar circumstances; but there are very few furnacemen in the country who would raise serious objection to the nodules on this score.

The following letter from Mr. P. J. Lynch, manager of the Toronto branch of Allis-Chalmers-Bullock, Limited, is of interest and gives any explanation necessary for a proper understanding of the estimate.

Several months ago we received an enquiry for data officially treating on the subject of magnetic concentration of iron ore.

It was only to-day that we were able to complete our data which we wish to offer you, and we are attaching hereto a copy of estimate for the mill and a list of the necessary motors to drive the mill, with the suggestion of either a 500-k.w. turbine or a cross compound engine direct connected to generator.

In regard to the installation of a de-sulphurizing plant, this part of the plant is a bare estimate, but we could in all probability furnish a satisfactory plant for the same as outlined.

The Allis-Chalmers Company in the United States have furnished practically all the machinery and equipment which is now being used in the magnetic separating of the magnetite ore deposits in the United States occurring in central and eastern New Jersey. One of the principal mills furnished by this company is known as the Lyon Mountain mill, otherwise the Chateaugay Iron Company operated by the Delaware and Hudson Railroad Company. This mill is handling fine disseminated magnetic iron ore which requires preliminary crushing to ¼-inch size, at which point the first magnetic separation begins. Unreleased parts of ore are then subjected to a finer crushing, and again magnetically separated, so that the extraction of the total magnetite contents of the ore will be higher than 80 per cent.

In some cases where the iron occurs in larger particles, magnetic separation can begin at one and one-quarter inch size. This is commonly known as "cobbing," and depends entirely upon the nature of the deposit to be handled.

The mill is entirely automatic in operation, the material being handled by conveyors and elevators, the concentrates being conveyed to proper concentrating bins and the dry tailings by stacking conveyors.

In common magnetic separation, it is necessary to dry the ore after crushing to the proper size, and this mill includes the necessary rotary dryers.

The mill would be adapted to handle from 1,000 to 1,200 tons of crude ore in 24 hours. The Allis-Chalmers Company have developed a special line of crushers and rolls, and our machinery is especially adapted for hard continuous work in separating iron ores, and as we have had the experience we are able to furnish a type of machinery which has proven satisfactory.

In quoting you a price for the above mill, we are giving you a quotation on a complete outfit, and are mentioning the different machines that would be required for

this work. The price of course is for machinery f.o.b. our factories Chicago and Montreal, and we cannot in any way give an idea of the cost of an erected plant, as local conditions govern and depend upon the character of mill site, kind of buildings to be used, and many other elements.

If my recollection is correct, you also requested some information on the de-sulphurizing of iron ores, as the magnetic deposits in Canada contain considerable sulphur. After the ore has been concentrated, the concentrates would then be passed to six 7 x 100-foot kilns, where the material would not only be de-sulphurized, but also nodulized by the use of powdered coal with the necessary tube mills, fans, feeders, etc. For such an equipment you will find the price and weight stated in the attached copy of estimate.

We are not making you a price on this machinery, but if it is required kindly advise and we will send you detailed prices on the above.

Details of Cost

Note.—Prices on concentrating plant and de-sulphurizing kilns, f.o.b. Chicago, price on power plant, f.o.b. Montreal. Grizzlies to be made of R. R. iron.

		Weight, lb.	
1 No. 8 Gates Breaker K—Manganese head and Comb Concaves		101,200	
1 No. 6 Ditto		47,050	
1 40 inch x 12 feet Gates Screen		9,040	
1 40 inch x 30 inch Rolls		50,000	
2 6 feet x 60 feet Dryers with stacks complete		160,000	
1 No. 8 Gates Elevator—50 feet ctrs		16,900	
Structural steel storage bins for dried ore, 50 tons		100,000	
4 Style H wall type feeders		2,220	
4 Sets 40 inch x 15 inch Anaconda Rolls		152,000	
2 40 inch x 16 feet Gates Screens with dust jackets		20,000	
2 18 inch Mill Elevators—60 feet ctrs		11,150	
2 40 inch x 16 feet Gates Screens		20,000	
4 Sets 40 inch x 15 inch Anaconda Rolls		152,000	
4 Roller Type Feeders		2,000	
2 24 inch coarse cobbing magnetic drum separators		8,000	
8 Belt separators		16,000	
Conveying System--including concentrates, storage system and tailings stacker system		75,000	
Shafting, Pulleys, Boxes, Belting, etc. for driving the above		150,000	
Drawings and Engineering			
		1,097,540	$90,351.00
Power and Motors:			
For Crushers	75 h. p.	3,680	
" Screen, big rolls and dryers	50 "	2,650	
" 4 roughing rolls	75 "	3,680	
" 4 screens, elevators	40 "	2,335	
" Finishing Rolls and Separators	100 "	5,000	
" Conveying system	60 "	2,860	
	400	20,205	$5,282.00
80 per cent. Power Factor:			
1 500 k. w. Cross Compound Engine		107,000	$17,500.00
For de-sulphurizing kilns, based on 1,000 tons crude ore 80 per cent. extraction; 800 tons, from 50 per cent. to 65 per cent. FE_2O_3 or 600 tons concentrates			
6 7 feet x 100 feet kilns complete with stack		780,000	
Coal pulverizing system		75,000	
Elevators for concentrates and pan conveyor for hot nodules and de-sulphurizing ore		100,000	
		955,000	$57,000.00

IV.—Manufacture of Iron and Steel in Ontario

Before attempting a description of the various iron works operating throughout the Province, it may be desirable first of all to make some explanation concerning the various processes by which the crude ore is converted into pig iron, and subsequently into the finished steel.

A bare summary only can be given here. If fuller information is desired the reader should consult some of the standard text books on the subject, a list of which will be found at the end of this report.

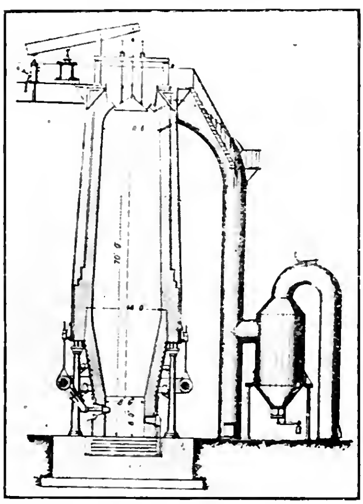
The Process of Smelting Iron Ore

Iron ore as it is mined from the ground is natural iron rust, a combination of iron and oxygen, and if we take away the oxygen the iron is left by itself. Carbon in any form possesses the power of breaking up this compound of iron and oxygen, by uniting with the oxygen and setting the iron free. In actual practice this carbon may be

coke, charcoal, anthracite or bituminous coal. When any of these fuels are mixed with iron ore and heated red hot, the separation of iron and oxygen takes place. This is, however, only the initial stage of the process. In order to melt the iron and separate it from the earthy parts of the ore and the fuel ash, another substance, limestone is added; the lime combining to form a fusible slag with the earthy portions of ore and fuel, the whole operation being conducted in a huge shaft from 75 to 100 feet high, called a blast furnace, filled with alternate layers of fuel and iron ore mixed with limestone, a superheated air blast entering at the bottom.

The Blast Furnace

The modern blast furnace consists of a large cylindrical tapering steel shell carried on a mantle supported by massive cast iron columns, the steel shell being lined with fire brick; and a lower portion below the mantle also constructed of fire brick bound with iron bands, tapering to a circular well at the bottom. That portion of the



A semi-modern blast furnace equipped with single bell and hopper, showing dust catcher attachment.

furnace above the mantle is called the "stack," below the mantle the tapering section is termed the "bosh," and the straight circular part below the bosh is called the hearth or crucible of the furnace.

Reactions in the Furnace

The raw materials are charged at the top, the furnace being kept full all the time with a column of fuel, ore and limestone, fresh additions being made from time to time as the column sinks by reason of its lower section being melted away with the heat developed in the region of the bosh. The air previously heated to redness enters at the bottom and meeting the fuel, the oxygen of the blast is quickly converted into carbonic oxide gas by re-acting with the carbon, as follows:

$$C + O = CO,$$
$$\text{or } C + 2O = CO_2,$$
$$CO_2 + C = 2\ CO.$$

This volume of gas sweeps up through the column of descending materials, re-acting with them in a gradually lessening degree as the top or cooler part of the furnace is approached. Almost as soon as the iron ore enters the top it is attacked by the carbonic

oxide gas, reduction of the ore being accomplished in a cycle of reactions of which the following are representative, in the order in which they occur:

$$3\ Fe_2O_3 + Co = 2\ Fe_3O_4 + CO_2,$$
$$Fe_3O_4 + CO = 3\ FeO + CO_2,$$
$$FeO + CO = Fe + CO_2.$$

All of the ore, however, is not completely reduced by the gases and descends until reaching a temperature of about 750 degrees F., when it is attacked by solid carbon, according to the following reaction:

$$Fe_2O_3 + 2C = 2\ FeO + 2\ CO.$$

At a still lower point where the temperature is about 1,300 degrees F., solid carbon begins to reduce FeO as follows:

$$FeO + C = Fe + CO$$

At about 1,475 degrees F., practically all of the iron is in a spongy metallic form, and at this point the limestone which was charged at the same time as the ore begins to be decomposed by the heat:

$$CaCo_3 = CaO + CO_2.$$

The carbonic acid gas from the limestone joins the other furnace gases, while the lime combines with the earthy impurities of ore and fuel forming a fusible slag, which trickles down and collects in the hearth.

During the time the ore is being reduced the spongy iron is absorbing carbon which lowers its melting point until finally it is sufficiently liquid to run down through the white hot fuel below, absorbing more carbon and trickling into the hearth along with the slag. The iron, being the heavier, sinks to the bottom of the crucible, while the slag floating on its surface is drawn off from time to time through an opening in the side of the hearth. If the furnace is in good working order, no unreduced ore or raw limestone will exist below the upper portion of the bosh, the bosh and part of the hearth being filled with incandescent fuel.

In order to protect the brick work of the bosh against the scouring action of the hot slag, it is provided with a series of hollow wedge shaped bronze castings, through which cold water is kept circulating. The hearth is protected by a circular steel jacket cooled by exterior water sprays. Other devices of bosh and hearth cooling are in use, but the above are typical of modern practice.

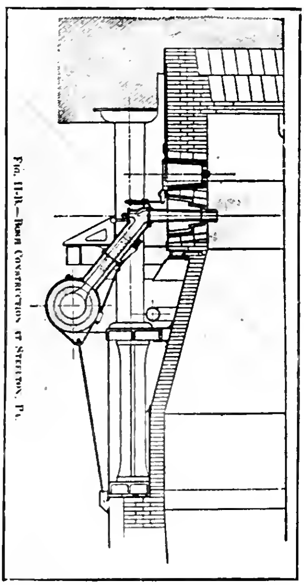
The heated blast is delivered from the stoves through a large pipe main encircling the furnace just below the mantle, called the bustle pipe, the air being conveyed in short goose neck connections from the bustle pipe to circular openings in the hearth called tuyere holes. The tuyeres proper are hollow, circular castings of bronze, projecting a few inches into the furnace, and are supplied with a constant stream of cold water, the tuyere and the goose neck connections from the bustle pipe being joined by short cast iron tubes termed blow pipes or belly pipes. To protect the tuyere openings in the brick work, large hollow bronze castings called tuyere coolers, encircling the tuyere and blow pipe, are placed in these openings extending through the total thickness of the brick work to the inside of the furnace. The tuyere coolers are also supplied with a constant stream of cold water.

The iron is tapped from the furnace every four or six hours, depending on the amount made, from the iron tapping hole, which is placed in front of, and at the lowest point of the hearth. After casting, this hole is usually plugged with balls of fire clay, forced into the opening by means of a steam ram, termed a mud gun.

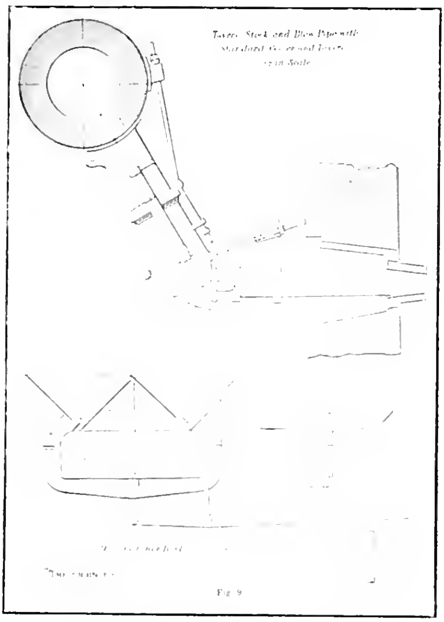
The slag is allowed to run off at regular intervals, through an opening in the side of the hearth called the cinder notch placed about a foot below the tuyeres. The cinder notch opening is protected by a water cooled circular casting of the same type as the tuyere coolers, and is provided at its inner end with a smaller casting, much like a tuyere, projecting into the bath of slag, the outer casting being termed the cinder

cooler, and the inside smaller casting, the cinder monkey. The slag flows through the cinder monkey to a trough leading to the ladles or cinder pit, the monkey being stoppered with an iron plug called a bot, when the furnace gives no more slag. This operation of allowing the slag to run off is described as flushing.

In former times furnace tops were open, consequently the waste gases escaped into the atmosphere and were lost. In modern practice the waste gases issuing from the top of the furnace are conducted to the ground level by a large pipe main, termed the downcomer, which at its lower end enters a huge cylindrical apparatus called the dust catcher. The dust catcher, as its names implies, is for the purpose of cleansing the gas as far as possible from dust, and is connected with the boiler room and hot blast stoves by separate mains, conducting the gas for use under the boilers in the making of steam and to the hot blast stoves for the purpose of heating the blast.



Blast furnace ; bosh construction.



Blast furnace ; tuyere attachments.

The Hot Blast

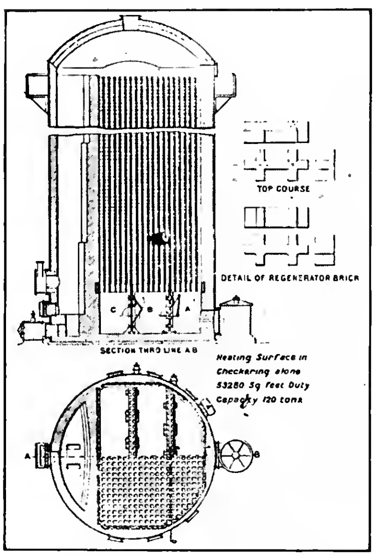
The hot blast stoves of which there should be at least three, and preferably four, to each furnace, are large, air-tight steel cylinders from 60 to 100 feet high and about 20 feet in diameter. These stoves are generally divided into two fire brick sections, a combustion and a checker work chamber, the latter containing some hundreds of small vertical flues, in construction resembling a honey comb. Gas and air are admitted to the bottom of the combustion chamber; the products of combustion pass up this chamber and down through the system of checker work flues, bringing the brick work to a red heat and finally escaping through a chimney valve to the draft stack. After the stove has been heated in this manner for an hour, the gas and chimney valves are closed, and the cold blast from the engines admitted passing through the checkers in the opposite direction to that in which the gas travelled, absorbing heat from the hot brick and flowing out through a hot blast valve to the air mains leading to the furnace bustle pipe. At the end of the second hour, the next stove which has been undergoing the heating up process is put on air, and the stove which has just been used for heating the air is again put on gas; the cycle proceeding in rotation with all three or four stoves. In this way

the blast is raised to a temperature of 1,200 degrees F. or over, as may be required by the furnaceman; the degree of heat being registered by pyrometers and controlled by the stove tender.

The blast is supplied by large blowing engines ranging from 500 to 2,500 h.p. each, capable of delivering from 20,000 to 50,000 cubic feet of free air per minute at a pressure of from 10 to 30 pounds per square inch. Furnaces using coke as fuel usually require from four to five tons of air for the production of each ton of pig iron.

The boiler plant, for generating steam to supply the blowing engines and other auxiliary engines about the plant, should be of ample capacity to meet all possible requirements, and the boiler settings should be designed wth the view of burning the furnace gases in an economical manner.

Of late years large gas blowing engines have been installed at many German plants, and at a few English and American steel works, the inefficient and costly boiler batteries being replaced by gas washing apparatus which thoroughly cleanses the gas before it goes to the engines. In this way a great deal of surplus power is generated electrically, which may be transmitted to more distant points.

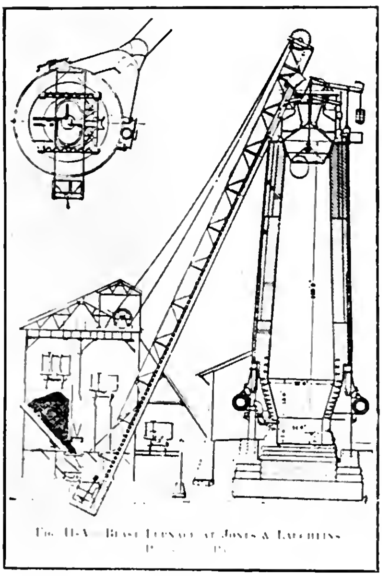


A blast furnace hot blast stove.

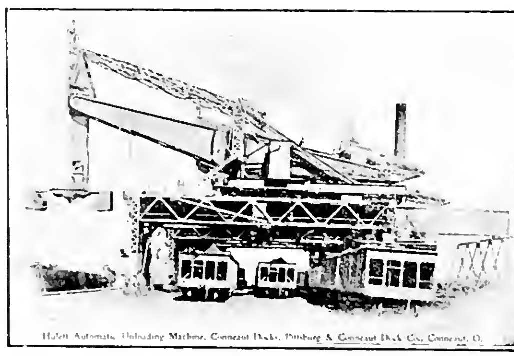
Charging the Furnace

The modern furnace is equipped with an incline skipway hoist and an automatic top-charging gear for handling the 2,000 tons or more of stock, used daily in one of the larger furnaces. The skipway is provided with two cars that are alternately being filled at the ground level and discharged into a receiving hopper at the furnace top. At the foot of the skipway, and extending for some distance on either side, is a series of bins or pockets, provided with a system of railroad tracks over their tops, connecting with the general yard. The ore, coke, and limestone cars are transferred over and dump their contents into the bins, the furnace supply being drawn off through bottom chutes into an electrically operated scale car, that weighs the ore and limestone automatically and transfers them to the skipway where they are dumped into the skip cars and hoisted to the top. The coke supply is held in the largest bins immediately next to the skipway and is chuted direct into the skip cars, the chutes being provided with screens arranged to get rid of dust and breeze (fine coke).

The furnace top is usually equipped with two superimposed receiving hoppers each provided with an iron cone called a bell, closing the hopper bottoms. The upper or small hopper receives the ore first and when full, its bell operated by a lever and counterweight is opened, discharging the contents into the lower hopper, This operation is repeated until enough stock has been hoisted for one charge, then the upper bell remaining closed, the lower or main bell also operated by lever and counterweight is opened, and the charge precipitated into the furnace. In this way the furnace gases are prevented from escaping during the operation of charging. Sometimes an additional piece of apparatus called a distributor is added. Briefly described, this consists of a sheet steel cylindrical casing, mounted on rollers above the large bell and free to revolve about its vertical axis. The inside of this casing is provided with a deflecting chute so arranged that when a skip load of stock is dumped into the distributor, the material is deposited over a certain sector of the charging bell below; the distributor is then revolved through an angle of say 90 degrees, and the next skip load of material



A modern blast furnace equipped with automatic charging gear.



Hulett automatic ore unloading machine.

deflected so as to cover the adjacent sector. By repeating this operation for each skip load, it is apparent that an even distribution of material around the bell is obtained, the coarse and fine particles being averaged evenly throughout the charge. An even distribution of stock is of vital importance for the efficient operation of the furnace, because if the coarse and fine material are not evenly distributed the ascending gases will rush through the side containing the coarser material, causing faster working than on the opposite side where the material is finer. This will result in a very irregular condition throughout the furnace from the top to the hearth.

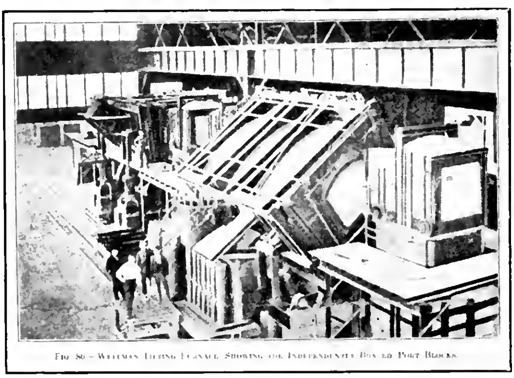
Making the Cast

When the furnace is ready for casting, an opening is made in the tapping hole, several men drilling through the clay plug by means of long drills and hammers. Out of this hole will flow the iron and with it a considerable amount of slag, through a short iron trough to a sand runner (ditch) where it meets the dam and skimmer. The skimmer is an iron or fire brick plate placed across the runner within a few inches of

the dam and between it and the tapping hole, the iron flowing underneath this plate and over the dam; the slag by reason of its floating on top of the iron is deflected by the skimmer to one side and flows to the cinder ladles.

Foundry iron (iron for foundry purposes) is usually cast in sand because then the pigs have a coarse open grain desired by all foundrymen. A large cast house in front of the furnace contains the casting floor, which is made up as follows: A long narrow ditch or runner is dug from the end of the casting trough down the centre of the house, and from the runner, smaller channels called sows are run about every four feet at right angles, to the side of the house; these each supplying 20 or 30 moulds that lie between and at right angles to successive sows. One sow and its compliment of moulds called pigs, is termed a bed or comb, and there may be anywhere from 15 to 35 beds at one cast, holding from 30 to 70 tons of iron

After the iron has cooled down to red heat the pigs are pried off from the sows by steel bars, the sows broken up into short lengths, and the whole cast cooled by water sprays. The iron is then conveyed to railroad cars alongside the cast house and shipped. The latest practice for handling the iron is to pick up each comb of pigs when cold, by an overhead travelling crane, which carries them to an hydraulic pig breaker placed



A Wellman open hearth tilting furnace.

at the end of the cast house. This method has the advantage of being more rapid and is of course a saving of labor.

When Bessemer or basic iron is being made for subsequent conversion into steel, it is preferably not cast in sand, as the adhering silica (sand) would be detrimental in the steel making process. Accordingly the molten iron after it passes the dam is distributed to half a dozen brick-lined ladles standing on a standard gauge railroad track beside the cast house, and is taken to the steel works for direct use in the molten condition.

Sometimes the liquid iron is not wanted at the steel department, its disposal being provided for by a pig-casting machine. There are several types of these machines in use, but the most common are the Uehling, and the Heyle and Patterson. Their construction is essentially a long series of hollow cast iron moulds carried on an endless chain travelling over heavy sprocket wheels. The molds overlap each other slightly, the iron filling them successively as they travel slowly past the pouring platform. and are emptied by the chilled pigs falling out at the other end. This method of casting is specially applicable when the iron is afterwards used for steel making, but as the chilled pigs have not the open fracture of the sand cast pigs, the latter method is preferable in the manufacture of foundry iron.

Analyses of Pig Irons Used for Different Purposes

	Silicon Per cent.	Sulphur Per cent.	Phosphorus Per cent.	Manganese Per cent.	Carbon Per cent.
Foundry No. 1	2.5-3.0	0.02-0.05	0.3-1.5	0.2-1.6	3.0-4.0
Foundry No. 2	2.0-2.50	0.03-0.05	0.3-1 5	0.2-1.6	3.0-4 0
Foundry No. 3	1.50-2.0	0.045-0.05	0.3-1.5	0.2-1.6	3.0-4.0
Gray Forge	0.5 1.5	0.045-0.06	0.3-1.5	0.2-1.6	3.0-4.0
Malleable Bessemer	0.75-1.75	0.02-0.05	0.10-0 25	0.30-0.60	3.0-4.0
Bessemer	0.75-2.0	0.03-0.075	under 0.10	0.3-0.5	3.0-4.0
Basic Bessemer	0.53 1.C0	0.05-0.09	1.0-3.0	1.0-2.0	3.0-4.0

Pig iron produced in the blast furnace contains from 92 to 96 per cent. of iron and from 8 to 4 per cent. metalloids, which are carbon, silicon, phosphorus, manganese, sulphur, and sometimes copper, chromium and titanium. In this condition the iron may be used for ordinary foundry work, but as it is weak and brittle, it is unfit for extensive engineering purposes. Therefore, in order to purify the metal by converting it either into wrought iron or steel it must be subjected to some one or other of the following processes:

The Puddling Process

The essential feature of this process is the exposure of pig iron to a hot flame on a hearth composed of iron oxide (iron ore) whereby the metalloids combine with the oxygen of the ore leaving the iron practically pure.

The furnace constructed of fire brick is of a low rectangular design, provided with a grate at one end, fired with bituminous coal. The products of combustion rising over a bridge wall reverberate from the low roof down upon the charge of pig and ore contained in the hearth and escape through the chimney at the farther end. The furnaces are built either singly or in pairs back to back, the latter method being more economical, as it reduces the amount of heat lost by radiation.

The pig iron is charged cold through side doors, and is melted down as rapidly as possible. As soon as the iron is liquid the iron oxide (very pure iron ore or mill scale) is added, the whole charge being thoroughly mixed and cooled down until the temperature is about right for the slag to commence the oxidation of the phosphorus and silicon. As soon as this re-action starts light flames break through the layer of slag resulting from the oxidation of the carbon, and as the carbon monoxide forms more and more rapidly, the whole bath is violently agitated by its escape, this stage of the process being called the boil. During the boil the puddler stirs the charge continually with a long iron rabble, until finally most of the impurities are removed and the metal begins to "come to nature." The next step is the balling up of the mixture of slag and partially welded iron particles until three or four balls are obtained, each weighing from 100 to 200 pounds, the whole operation taking from one to two hours for each heat. The balls are then taken out of the furnace and are either squeezed by a mechanical squeezer, or shingled (hammered) to get rid of the larger portion of slag held throughout the mass and also to weld more firmly together the particles of iron.

The material thus obtained is called "muck bar" and is cut up into sections and piled, and after being reheated to a welding temperature is rolled again: this time forming the "merchant iron" of commerce

The Bessemer Process of Making Steel

This process consists of blowing cold air through a mass of liquid pig iron, the oxygen of the blast uniting with the impurities in the metal and resulting in the formation of gas and slag, the finished product being known as steel.

The operation is conducted in a pear shaped vessel lined with refractory material, called a converter. Air is admitted through numerous tuyere holes in the bottom, the blast pressure being sufficient to keep the metal from running into the openings. The

converter is carried by side trunnions on bearings suported by a stout iron framework and may be turned on its trunnions by a pinion, geared to a rack which is attached to a double acting hydraulic ram. The capacity of the vessel varies considerably, in small plants not holding more than five tons, while in the larger works converters holding 20 tons are frequently used.

The construction consists of a steel shell lined with refractory material about one foot in thickness. It is divided into three parts, called the bottom section, the belly, and the nose. The bottom section may be and is removed frequently for repairs to the tuyeres, which are rapidly worn away; the belly and nose sections lasting much longer are not disturbed until a complete re-lining is necessary.

Two distinct types of lining are employed depending upon whether the pig iron for conversion contains little or much phosphorus. If the iron does not contain more than 0.10 per cent. of phosphorus, the lining is made of silicious material, the blowing of the metal being then termed the acid bessemer process; but if the pig iron contains from 2.5 to 3 per cent. of phosphorus, the lining is then made of basic material, and

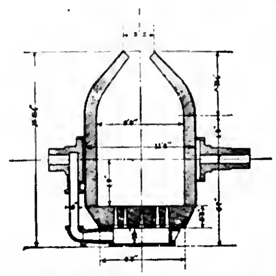


Fig. VI-A.—Section of Bessemer Converter in Upright Position.

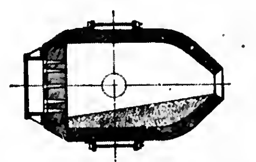


Fig. VI-A.—Section of Bessemer Converter when Turned Down, Showing Bath of Metal.

Bessemer converter in upright and horizontal positions.

the operation is called the basic Bessemer process. The essential difference between the two methods is, that no phosphorus is eliminated in the acid process, while in the basic process its removal is easily accomplished. Steel for engineering purposes should contain under 0.10 per cent. of phosphorus; if it contains more it is not trustworthy, and as the acid bessemer process will not eliminate phosphorus, pig irons, low in that element, are required in this method for the manufacture of first-class steel. Such irons are called Bessemer irons and usually command a high price.

The acid process is the one almost entirely used in America, the basic process being more generally applied in Germany and to a lesser extent in Great Britain.

The molten iron for the converter is supplied from a huge storage tank of steel lined with fire brick, called a mixer, holding from 150 to 300 tons of hot metal. This mixer is kept hot by gas and not only acts as a receiver but as its name implies mixes the various additions of pig iron made from time to time from the blast furnaces, thus averaging the quality of the metal. The hot metal is poured from the mixer into a ladle and conveyed to the converter, which is turned down to the horizontal position

to receive the charge. After the metal is poured in, the blast is started and the vessel is turned back into the vertical position, the air pasing through the 18 or 20 inches of metal, oxidizing the impurities and raising the temperature of the bath considerably. During the early stage of the blow a short flame appears at the mouth, gradually increasing in size and brightness until splashes of slag and some metal are ejected, affording evidence of the violent re-action going on inside the vessel. This is called the "boil," and is due largely to the evolution of carbonic oxide from the combustion of the carbon in the metal. Gradually the action becomes less violent and the flame drops, finally disappearing almost entirely, this stage of the process being known as the "drop of the flame." The converter is then turned down immediately to the horizontal position, and the blast of air is stopped. The metal is now almost entirely rid of the impurities that existed in the original pig iron, but if poured in this condition would give considerable trouble in rolling and be unfit for use. Therefore an alloy of manganese, iron and carbon called ferromanganese, or a similar alloy containing less manganese called spiegeleisen is added, which raises the carbon content of the steel to the desired point. Ferromanganese is usually added in small lumps if mild steel is being made. For steel rails spiegeleisen is always added, being melted down in a cupola before it is charged to the bath. Whichever alloy is used, the function of the added material is the same, *i. e.*, to raise the carbon content of the metal and also to eliminate a large amount of oxygen contained in the steel resulting from the blow. The exact proportion of ferromanganese or spiegel necessary for these re-actions is carefully calculated beforehand, so that the finished steel shall have the desired chemical composition.

The metal is now poured into a brick-lined ladle which is picked up by an overhead crane and the steel teemed into a row of cast iron ingot moulds, standing on small cars. When the ingots are sufficiently solid they are taken to the stripper, which consists of a machine operated either electrically or by hydraulic power for pulling the iron moulds from off the ingots. The stripped ingots then go to the soaking pits, which are large hole furnaces, the ingots remaining in the soaking pits until the heat is evenly distributed throughout so that it will work well under the rolls. From the soaking pits the ingots are conveyed to the rolling mills and are rapidly worked into finished articles, such as rails, structural shapes, plates, wire, etc., etc.

The Open Hearth Method of Steelmaking

In this method of manufacturing steel the impurities in the pig iron are not eliminated by blowing air through the metal as in the bessemer converter, but are got rid of by the action of gas, and slags formed by the addition of pure iron ore or limestone to the bath of metal.

The furnace consists of a large rectangular hearth built of refractory material, upon which the pig metal is melted and the process of its conversion into steel is carried out. At each end of this hearth are two chambers filled with fire brick checker-work, the pair of chambers at one end each conducting a supply of air and gas separately, which unite and burn in the hearth of the furnace, the products of combustion passing through the checker-work chambers at the opposite end, and heating the brick work to a high temperature. In a short time the direction of the flow of gas and air is changed, the supply being now admitted through the heated chambers, and the products of combustion passing out through the comparatively cold chambers at the other end. At regular intervals this alternation of the flow of gas and air is effected by means of reversing valves placed between the two chambers and controlled by the man in charge of the furnace.

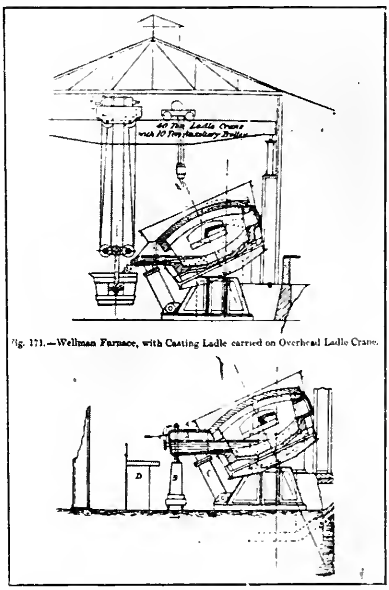
The central portion of the furnace hearth where the steel is made is called the laboratory, and the checker-work chambers are called regenerators, the furnace being constructed on what is called the regenerative principle.

The regenerators are the essence of this Siemens type of furnace; they store up heat, caught by the large surface of brick work, from the escaping gases and return

it to the furnace on the next reversal of gas and air. In this way the regenerators are heated to approximately 2,000 degrees F., giving up their heat to the air and gas, which entering the furnace in a highly pre-heated condition, produce in the laboratory of the hearth a temperature of about 3,000 degrees F.

The original furnace as devised by Siemens was stationary, the regenerators and hearth being connected by solid brick work construction, and the finished steel tapped out through a hole in the bottom of the hearth. Later types invented by Campbell and Wellman are constructed so that the hearth may be tilted, the hearth being built separately from the regenerators, rolling on steel rockers or turning on rollers about its central axis, the tilting being controlled by hydraulic power. Both types have certain advantages which may be summed us as follows:

Stationary furnaces are cheaper to build and last much longer, the frames, roofs, ports, etc., etc., not being subjected to the heavy strains experienced in the tilting types. Tilting furnaces, although more expensive to instal and keep in repair, have



Wellman tilting furnace showing casting ladle.

the advantage of being able to cast their contents at a moment's notice, the tap hole being above the bath. This is a valuable factor in making certain special steels. There is no trouble in opening the tapping hole so often experienced in the stationary type, and as the bottom may be drained by tilting the furnace, repairs are easily accomplished.

The fuel is usually supplied by a battery of gas producers, placed behind the furnaces, the size and number of producers depending upon the requirements of the system of furnaces. Natural gas is also used, and because of its cheapness and calorific value is highly esteemed. Coke oven gas and crude petroleum are utilized to some extent, but in the majority of plants operating in America the fuel is either producer or natural gas.

Acid Open Hearth Steel

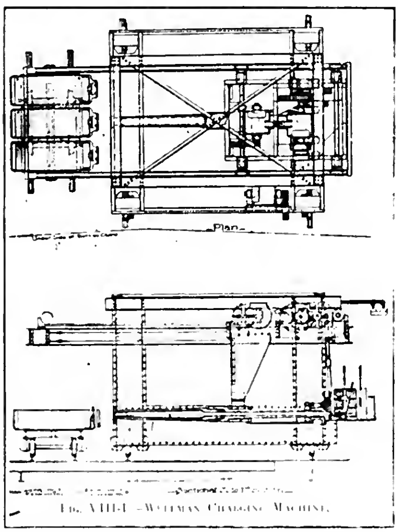
There are two distinct methods in open hearth practice, called respectively the acid and basic open hearth processes. In the first method the furnace hearth is lined with silicious material and a mixture consisting of pig iron and scrap is charged and melted; no limestone is used for flux, but when the mass of iron is liquid, iron ore is added in large or small amounts as may be required, the oxygen of the ore combining

with the carbon in the metal until the required composition of steel is obtained. Silicon and manganese in the pig iron are also oxidized, forming a slag with the oxide of iron supplied by the reduction of the ore and also by the oxidation of some of the iron in the charge. Neither phosphorus nor sulphur are eliminated, hence if steel of bessemer quality is desired, the stock is selected containing only small amounts of these elements, phosphorus under 0.1 per cent. and sulphur below 0.05 per cent.

For recarburizing, a rich ferromanganese is used: this is usually thrown into the ladle as the heat is being tapped from the furnace.

Basic Open Hearth Steel

In the basic open hearth furnace, the hearth is lined with basic material such as burnt dolomite or magnesite so that a very basic slag may be carried without injury to the lining. The charge consists of pig iron and scrap to which is added a certain



The Wellman open hearth charging machine.

amount of lime or limestone; iron ore is also used for oxidizing purposes, and a little fluor spar is added occasionally to effect a proper fluidity of slag.

The practice of charging varies, but generally the limestone is first put in, then followed by the ore, scrap and pig iron, the whole charge being melted down with later additions of ore and limestone as may be required. The silicon, manganese, and some of the iron, are oxidized just as in the acid process, but instead of making a slag by themselves, the silicon and oxides of iron and manganese unite with the lime that has been added, forming a basic slag, which will hold the phosphorus as it is oxidized. Sulphur is eliminated in the same way, but in a very much less degree. After the metal has reached the desired composition, it is tapped into the ladle with the addition of ferromanganese, as in the acid process.

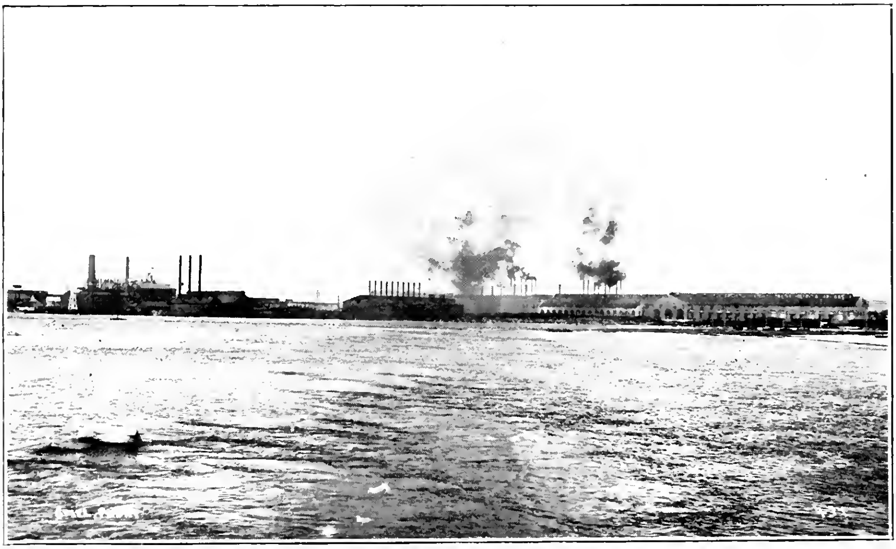
The modern method of charging cold stock in the open hearth furnace, is by means of an automatic machine operated electrically on a railroad track extending along the front or charging sides of a battery of furnaces. The best known and most widely used type of charging machine on this continent is the Wellman. Essentially, this machine consists of a long charging bar equipped with a foot at one end which is caught in a socket on the charging box, lifting the box and thrusting it through the open doors of the furnace. The bar is then rotated and the contents of the box emptied on the hearth. The empty box is then withdrawn, and another is lifted and charged in like manner, the operation being continued until the whole of the stock has been charged

Charging and Mixing

If hot metal is used it is conveyed from the blast furnace to the mixer, and then taken as required to the open hearth department in large hot metal ladles. An opening is provided in the back of the furnace with an exterior lip basin for receiving the molten iron from the charging ladle as it is slowly poured into the hearth.

The time required for one heat varies greatly, and depends upon the different conditions of stock used, furnace operation and fuel supply. Generally speaking, ten hours would be considered good work for a furnace of 50 tons capacity, and 20 hours would be considered poor work

After the steel is tapped, the ladle is picked up by an overhead crane and the metal is teemed into a row of ingot moulds. When the metal has solidified the moulds are removed to the stripper, where the ingots are stripped and sent to the soaking pits and afterwards to the rolling mill.



Algoma Steel Company, Sault Ste. Marie. General view of works.

The Algoma Steel Company, Limited

This company, owned and operated by The Lake Superior Corporation, has the largest of the existing iron and steel works in Ontario, both as regards tonnage produced and amount of capital invested.

The plant is located at Sault Ste. Marie on the St. Mary's river, a short distance above the rapids and consists of two blast furnaces with all necessary modern stock handling machinery, two acid bessemer converters, two basic open hearth furnaces and a rail mill with a capacity of 225,000 tons annually.

Work on construction was begun in 1901, the bessemer and rail mill departments being erected first, and operated entirely on pig iron brought in by boat and rail from Ontario and American blast furnaces, until the company's No. 1 blast furnace was completed in 1905 and No. 2 in 1906. At the present time the steel making departments require more iron than the blast furnaces can supply, necessitating the buying of considerable amounts of pig in the open market. The company intend to correct this inadequacy by building two additional blast furnaces in the near future. The open hearth department was constructed in 1906-1907, and has proved a valuable auxiliary to the bessemer department.

The ores used are obtained almost entirely from the Lake Superior American ranges. A small amount only of Helen ore is smelted, as it contains too much phosphorus for the bessemer process. Several small shipments have been received from the Wilbur mine in eastern Ontario, this being the only native bessemer ore used at present.

It was originally intended to manufacture charcoal for the blast furnaces, and No. 1 furnace for a time operated on this fuel, but it was found very difficult to supply the necessary amount, and coke had to be substituted. Accordingly Pocahontas coke from the West Virgina fields is brought in by rail, and this imported coke will be used until the company instal a coke oven plant, which is under consideration. Limestone is quarried in Michigan about 40 miles from the Sault and is brought in by rail. This stone serves for both blast furnace and open hearth use.

The following approximate analyses will give some idea of the quality of the ore, coke and limestone:

Material.	Fe	Al_2O_3	SiO_2	Phos.	Mn	CaO	MgO	S	$CaCO_3$ $MgCO_3$	Fixed Carbon	Ash	Vol.
Ore	55-60	2.00	7.00	0.035	0.1	0.50	0.97	0.03				
Coke										89.4	8.07	2.3
Stone									96-98			

The Blast Furnaces

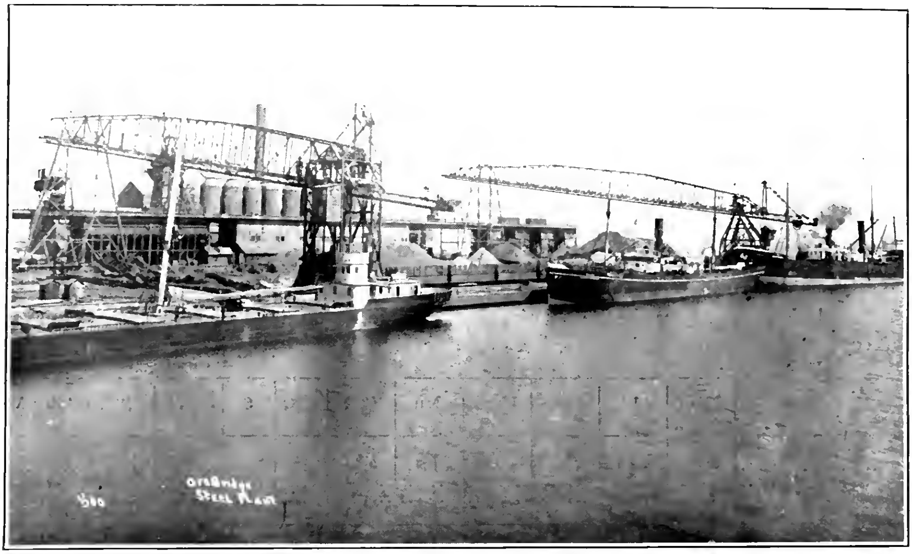
The ore docks lie behind the blast furnaces. They are 1,600 feet long with 20 feet of water alongside and are equipped with two Wellman-Seaver-Morgan unloading bridges. These bridges have a span of 293 feet, and are 84 feet high at the inner end and 50 feet high at the water end. The power for moving the bridges and operating the grab buckets is supplied by a pair of 130-h.p. electric motors installed in cabins which are built on the short legs of each bridge, all operations being controlled from these points. The capacity of each bridge for unloading and re-handling from the stock piles to the furnace bins is approximately 1,000 tons for 24 hours. The storage capacity of the ore yard is about one half million tons.

The blast furnace storage bins are of the Berquist type, 32 in number, 16 for each furnace. They are 40 feet high, substantially built of brick and steel. Eight pockets are used for ore, holding when full 3,000 tons, the remainder being used for coke and limestone. The ore is conveyed by the bridge clam-shell buckets and is dumped into the pockets through movable chutes that run on a steel trestle above the line of the pockets. Or if the pockets are full the ore as it is unloaded from the boats is dumped on the stock piles, to be picked up again as required. Coke and limestone cars are shunted on to the bin trestle, which connects with The Algoma Central and Canadian Pacific railways, the contents being dumped direct into their respective pockets. The system is provided with chutes on the blast furnace side, through which the stock is discharged into the furnace skip buckets. The buckets are detached from the skip hoist and placed on electrically operated transfer scale cars running alongside the pocket chutes, which are provided with independent gates.

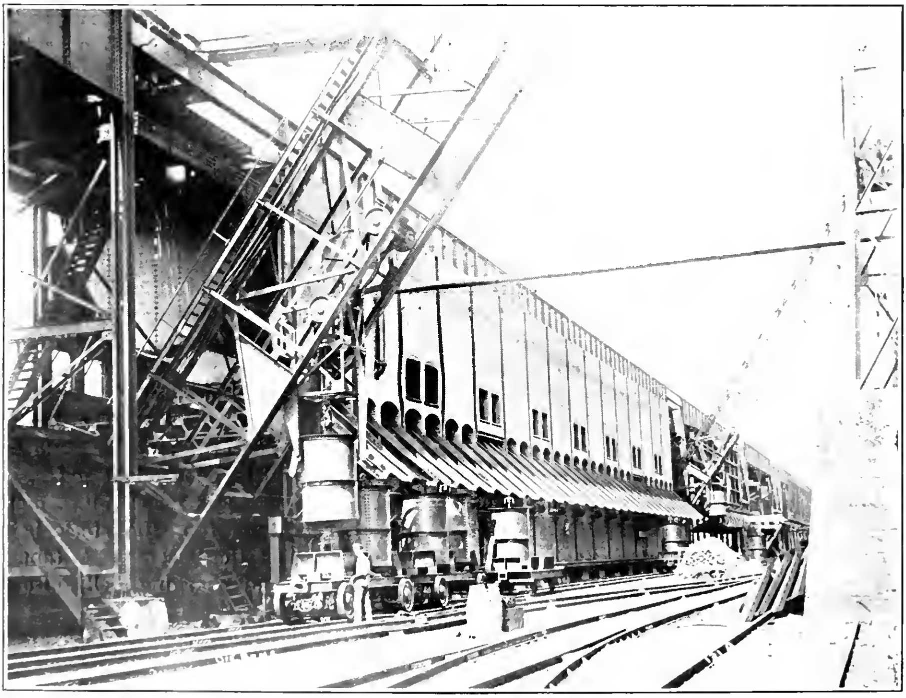
Each furnace is equipped with a bucket skip hoist operated by a 135-h.p. motor controlled from the ground floor. No distributor is used on top, the stock being dumped direct on a single bell through the drop bottoms of the buckets. A topman is employed on each furnace for operating the buckets and charging bell, also to gauge the height of the stock in the furnace.

The two blast furnaces are on a line parallel with the bin system. They are of the following dimensions:

No. 1.		No. 2.
70 feet	Height	80 feet.
17 feet	Bosh	17 feet.
11 feet	Hearth	11 feet.
10 feet 5 inches	Throat	10 feet 5 inches



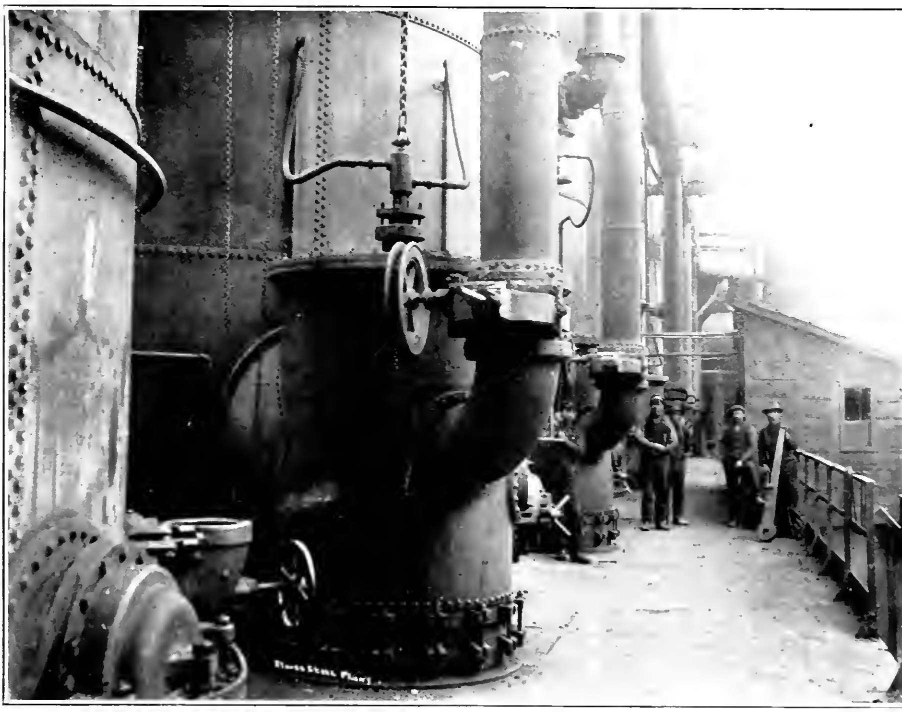
Algoma Steel Company, Sault Ste Marie, Ont. Ore bridges at the docks, blast furnaces in background.



Algoma Steel Company. Bottom of skip hoists for Nos. 1 and 2 blast furnaces, showing bin system and method of filling buckets.

Both furnaces are of the ordinary modern construction—a steel shell carried on cast iron columns. The hearths of both furnaces are encased in steel jackets, water cooled both inside and out. The bosh on No. 1 is covered with a steel casing cooled by water spray on the outside, that of No. 2 furnace is fitted with modern bronze water cooling blocks, and both furnaces are cooled for 9 feet above the bosh in a similar manner. Each furnace is blown through nine 5-inch tuyeres, with an approximate volume of 20,000 cubic feet of air per minute, the blast pressure at the tuyeres being from 9 to 12 pounds per square inch.

Between the furnaces and in line with them are 7 hot blast stoves, each of which is 18 feet in diameter and 70 feet high. These stoves are of the two-pass Foot type, and will heat the blast to 1,400 degrees F. The hot blast and chimney valves are



Algoma Steel Company. Base of hot blast stoves, showing chimney valves.

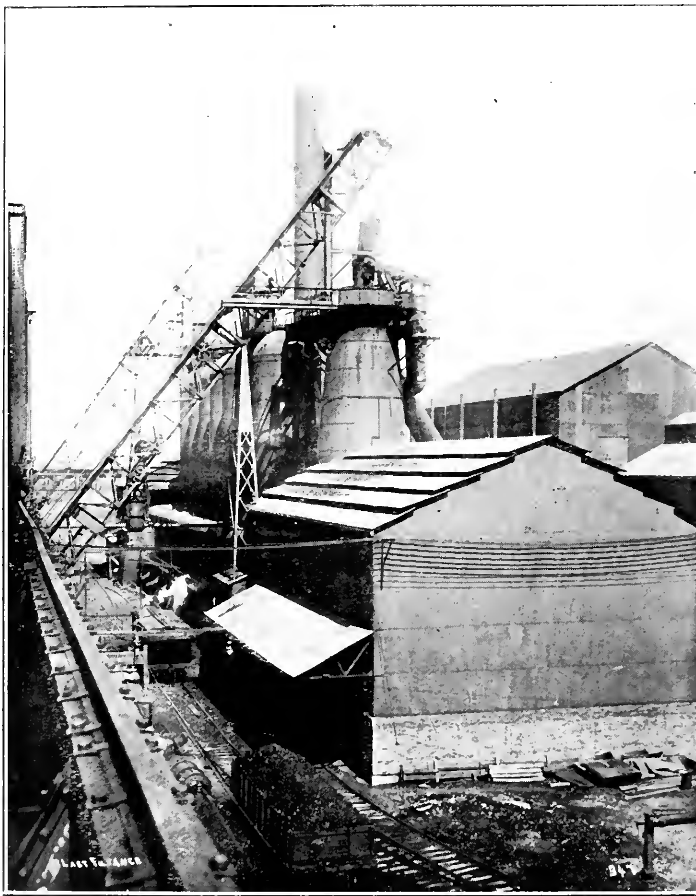
water cooled. A steel draft stack 150 feet high situated midway between the blast furnaces takes the chimney gases after their passage through the stoves. The stove system for each furnace is equipped with Uehling pneumatic pyrometers for air and gas; Bristol recording gauges are used for indicating the blast pressure.

The furnaces are provided with divided leg downcomers which enter large cylindrical dust catchers of the ordinary type. The dust mains from the dust catchers to the stoves and boilers are equipped with dust legs, at short intervals, so that the amount of dust which reaches the stoves and boilers is not excessive.

In front of each furnace are built the cast houses of steel and corrugated iron: sand casting is not practised at all. The hot metal is run into 20-ton ladles and taken to the mixer in the bessemer department. After casting, the tapping hole is

closed with an ordinary Vaughan notch gun. On Sundays or at any time when the bessemer department is not operating, the molten iron is conveyed to the pig casting machine. The furnace slag is also handled in ladles, and is carried to the cinder banks where it is used for filling and extending the general yard.

Both furnaces are operated for bessemer iron; the output from each furnace for six consecutive months is shown in the following table, and considering that the



Algoma Steel Company. Blast furnaces Nos. 1 and 2, showing bucket skip hoist.

coke consumption averages 2,300 pounds per long ton of iron, the results are indicative of good furnace practice.

The average tonnage of pig iron made per day, is shown by the following figures:[32]

1907.	No. 1 Furnace.	No. 2 Furnace.
July	128	249
August	Relining	224
September	204	236
October	221	258
November	240	258
December	245	212

[32] Iron and Steel Industry of the Province of Ontario, by Jas. G. Parmelee; Journal of the Canadian Mining Institute, Vol. XI.

The ore mixture consists of about 75 per cent. of Old Range and Mesabi bessemers, the remainder being Ontario ores, principally Helen and Wilbur. The yield of pig iron from this mixture will vary between 48 and 53 per cent. The charge is made up as follows:

Coke	5,400 pounds
Ore	10,000 pounds
Limestone	3,000 pounds

The blast furnace blowing engines are situated in a building alongside the furnaces. These are four vertical condensing engines of the Steeple Corliss type,

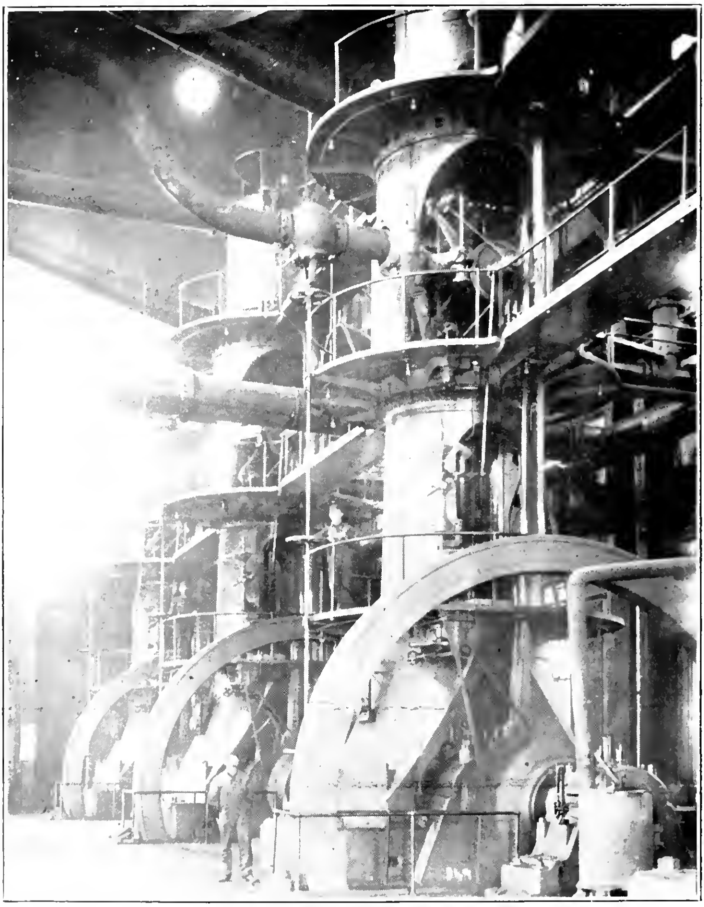
Algoma Steel Company. Top of No. 2 Blast Furnace, showing method of filling the furnace.

built by the Mesta Machine Company of Pittsburg, the steam cylinders being 44 inches in diameter, and air cylinders 72 inches diameter, with a 60-inch stroke. The air inlet valves of the blowing tubs are operated positively; the discharge valves are of the ordinary poppet type. At 40 revolutions the four engines will deliver 45,000 cubic feet of air per minute, and are capable of blowing against a pressure of 30 pounds.

The pumping plant for supplying the blast furnaces, also located in the engine room, consists of 3 Wilson-Snyder compound condensing plunger pumps, having a total capacity of 15 million gallons per day. The electrical equipment consists of

3 General Electric, 225 kilowatt generators, two of which are geared to the driving shaft of one of the blowing engines, and the third operated independently by a small auxiliary engine. The two generators driven from the blowing engine are only used in case of emergency, when trouble is experienced at the main generating plant of The Lake Superior Power Company. The engine room is equipped with a 15-ton electric crane built by The Whiting Foundry and Machine Company.

Steam is supplied to the engine room at 125 pounds pressure from an adjacent boiler house containing a battery of 12 Cahall vertical water tube boilers, with a



Algoma Steel Company. Blast furnace blowing engines.

combined capacity of 3,000 h.p. The boilers are arranged in sets of two, three, three and four respectively, and each boiler is equipped with a 40-foot stack, 36 inches in diameter. Blast furnace gas is burnt, with the Kennedy horizontal valve, coal being used for auxiliary firing.

The Heyle and Patterson three stand pig casting machine is installed in a steel building about 800 feet distant from the blast furnaces. This building also serves as a ladle repair shop. The casting machine is fed directly from the 20-ton iron ladles, which are picked up and tilted by a 40-ton overhead electric crane, the metal flowing through small runners to each stand of the casting machine. The machine is

driven by a 30-h.p. electric motor at the delivery end. The chilled pigs fall on flat cars, which are shunted to the iron stock piles near the Bessemer building. Here the pigs are unloaded by a crane derrick, equipped with an electro-magnet that will easily lift one ton. By this means the iron is transferred to the stock piles with ease and rapidity.

The Steel Plant

The basic open hearth department consists of a large steel and corrugated iron building containing two 40-ton Wellman-Seaver-Morgan stationary furnaces, the foundations for a third furnace being in place. This department is located so that additional units may be added as required. The stock enters the building by an elevated incline standard gauge road, and is charged to the furnaces by a Wellman-Seaver-Morgan electric charging machine of the well known box type. On the cast-

Algoma Steel Company. Basic open hearth building on the right; bessemer plant and rail mill on the left.

ing side the ladles are handled by a 60-ton overhead electric crane made by the Morgan Engineering Company. The steel is teemed into ingot moulds, which are then hauled to the electric stripper in the bessemer department. The ladles are repaired in the open hearth building and dried out afterwards with producer gas.

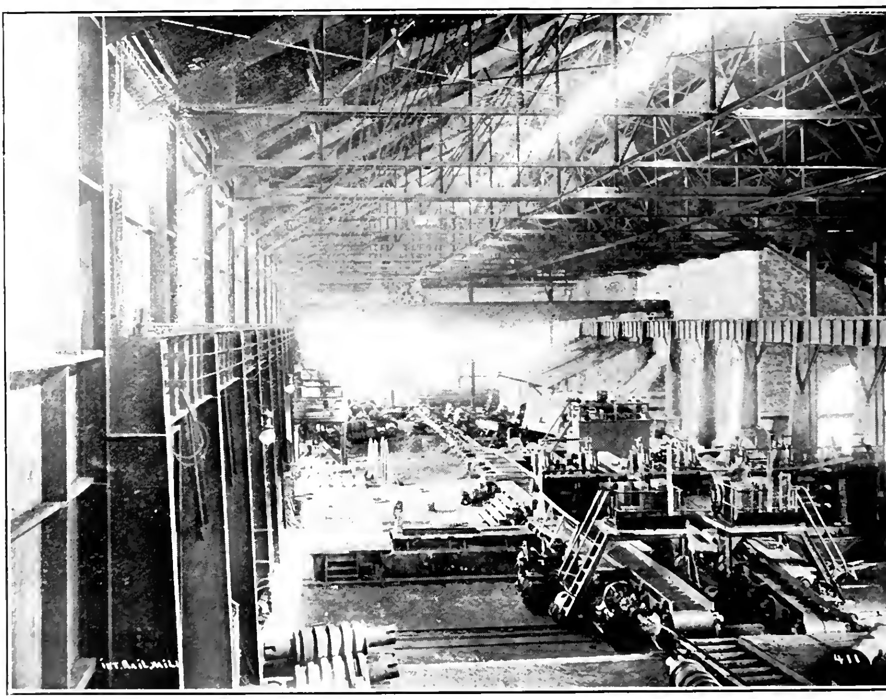
The eight gas producers situated immediately behind the open hearth building are of the ordinary water-sealed hand-poked type, 10 feet 6 inches in diameter. Coal is handled by a McMyler hoist outside the producer house, delivering to chutes which convey the fuel to the charging platforms.

The open hearth department has been operated only in May and June of 1907; the number of heats at that time averaged 28 per week. Pig iron for this process is bought outside, no basic iron being made at present by the Sault furnaces.

The bessemer department, steel rail and finishing mills, are installed in a series of red sandstone buildings with iron roofs, extending practically in a straight line adjoining one another.

The mixer building, constructed of steel and corrugated iron, is built against the bessemer building on the side next the blast furnaces. The mixer holds 150 tons of hot metal, a 40-ton electric travelling crane handling the iron ladles as they arrive from the blast furnaces on a standard gauge railroad.

Between the mixer and the bessemer converters there are seven cupolas—four of these, 8 feet in diameter, are used for melting pig iron for the converters, but are operated only when there is an insufficiency of hot metal from the blast furnaces. These iron cupolas have a capacity of 25 tons per hour. The other three, 5 feet 6 inches in diameter, are used for melting down spiegeleisen. Stock is hoisted to the cupola charging platforms by a pair of Otis electric elevators. The hot metal from the cupolas is cast into ladles on a level with the charging floor of the converters, and is either taken to the mixer, or if needed may go direct to the converters by an



Algoma Steel Company. Interior of rail mill, cooling beds in the distance.

electric trolley narrow guage system operating between the mixer, cupolas and converters.

The two 4-ton acid bessemer converters are mounted on a platform which is on a level with the bottom floor of the cupola house. Each converter is blown through bottom tuyeres by a pair of blowing engines, situated in a separate building, which supply the blast at a pressure of about 18 pounds. These engines have 40-inch steam and 54-inch air cylinders with a 48-inch stroke. From 80 to 200 heats are blown per day, the average time consumed for one heat being about 8 minutes.

The finished steel from the converters is poured into a ladle mounted on a hydraulic jib crane, and then teemed into the ingot moulds standing on small flat cars alongside. The moulds after being filled are taken to a Wellman-Seaver-Morgan standard electric stripper, and when stripped the ingots are placed in the soaking

pits. There are three four-hole gas-fired soaking pits, each hole having a capacity of 4 ingots. After remaining in the soaking pits until the centre of the ingot is solid and the heat evenly distributed throughout, the ingots are withdrawn by a pair of ingot tongs operated from an overhead electric crane, and conveyed to the blooming mill table. The cogging rolls are 32-inch, two high, and are driven by a pair of 28 x 48-inch Southwark reversing engines. The tables are driven electrically, and from a pulpit above the mill the engines, tables and manipulators are controlled. The blooms 8 x 8 inches are carried along the tables to the bloom shears and cut into sections of about 3,000 pounds each; these shears will make a maximum cut of 9 x 9 inches.

From the shears the blooms go to three horizontal re-heating furnaces fired with producer gas, contained in a building placed at right angles to the rail and blooming mills. The blooms are handled by two Wellman-Seaver-Morgan electric cranes, and after being heated are withdrawn by the cranes and placed on the tables of the rolling mill.

The building which contains the rail mill adjoins the heating furnaces and is parallel with the blooming mill building. The rail mill train consists of three sets of rolls,—two roughing and one for finishing. All the mills are three high and coupled together, being driven by a 40 x 48-inch Porter Allen, reversing condensing engine. Each section receives four passes in the first set of roughing rolls, four in the second and three final passes in the finishing set. The travelling tables serving the rolls on the front side are electrically operated. On the back side the tables are of the stationary tilting type, furnished by the Wellman-Seaver-Morgan Company.

From the finishing mill the rails are conveyed to the hot saws and cut to standard lengths. They are then stamped and cambered, and run on to the cooling beds of which there are two, each 140 feet long, running at right angles between the rail mill and the finishing department. The finishing mill runs parallel again to the rolling mills, and contains four straightening presses and eight drill presses, each press being driven electrically by an independent motor. The rails are conveyed by a roller table to any desired position along one side of the building and then skidded to the presses, the burrs being chipped off during the process of straightening and drilling. They are then loaded direct on flat cars to be shipped or stored as occasion requires.

The power for the steel mill is located in a building near by, and consists of two batteries of 8 Sterling boilers of 250-h.p. each, three gas producers of the Fraser-Talbot mechanical type, for supplying the soaking pits and re-heating furnaces, the bessemer blowing engines, cupola blowers and the necessary pumping machinery; the boilers, gas producers, engines and pumps being partitioned off from each other.

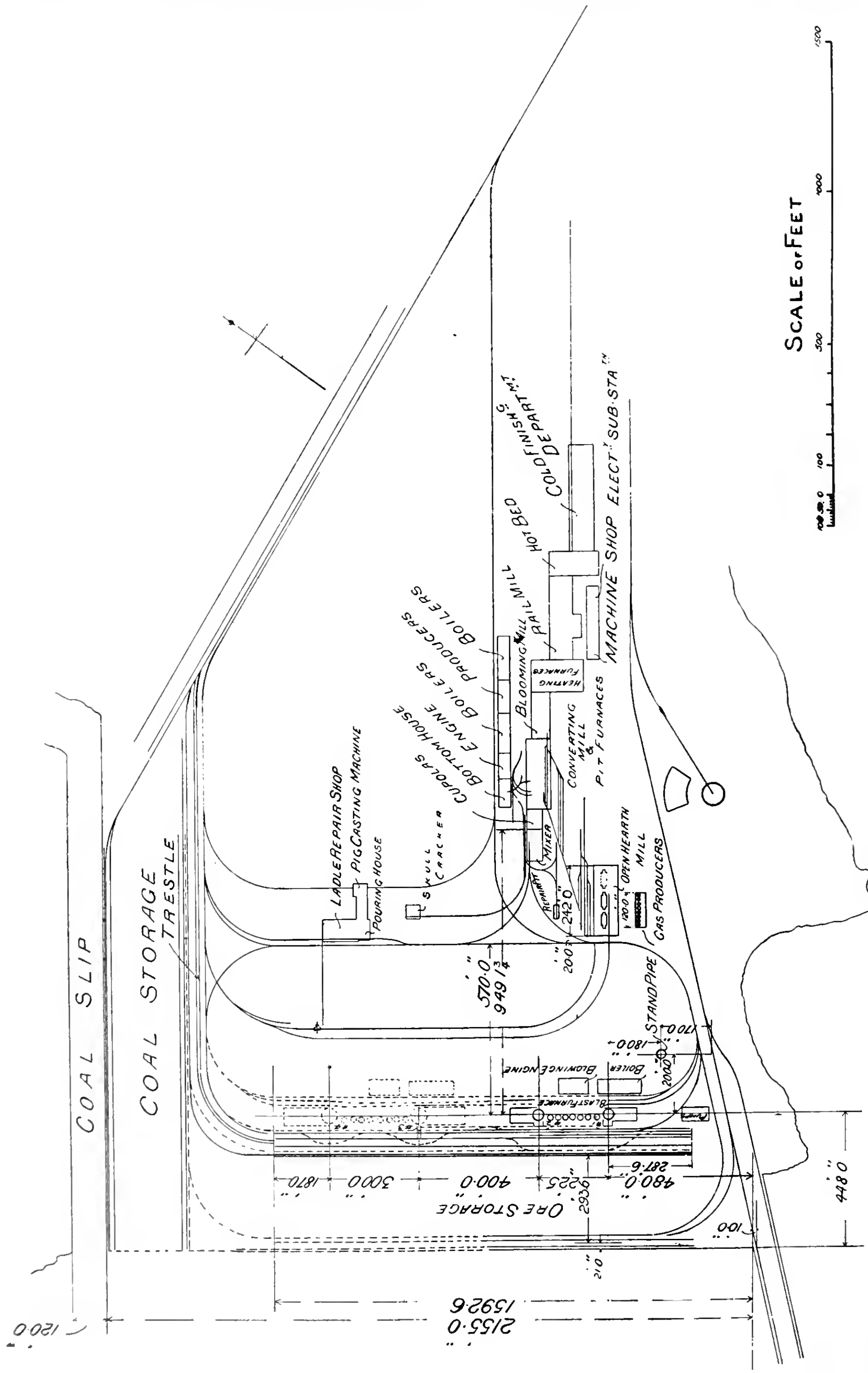
The capacity of the plant is rated at 225,000 tons of rails annually. The whole works are under the general superintendence of Mr. D. D. Lewis, to whom thanks are due for all information.

The rail mill can turn out rails of any desired section from 25 to 100 pounds per yard, but as the demand has been mostly for 60-, 75-, 80- and 100-pound rails, rolling has been confined to these sections.

The Hamilton Steel and Iron Company, Limited

The works of the Hamilton Steel and Iron Company, Limited, are located in Hamilton, on the shore of Burlington Bay, Lake Ontario, and in point of size and investment come next to those of The Algoma Steel Company.

The plant consists at present of two coke blast furnaces, four basic open hearth furnaces, puddling furnaces, rolling mills and a forging department, also a small spike mill.



Algoma Steel Company. General plan of works.

The old blast furnace, known as A., was first blown in on December 31st, 1895, and was the first coke blast furnace to operate in Ontario. The plant was worked for a time under the name of The Hamilton Blast Furnace Company, Limited, with more or less success, until in 1899 the company amalgamated with The Ontario Rolling Mills, another Hamilton industry; the new organization called The Hamilton Steel and Iron Company, Limited, operating both plants from that time forward under careful and efficient management. Various additions have been made during the last few years, increasing the capacity of the plant considerably; the latest and most important adjunct being the new blast furnace known as B., which was blown in on November 8th, 1907.

All raw materials are brought in by rail, the ores coming from Lake Superior are transferred to drop bottom steel cars at Sarnia on Lake Huron, where the company operate their own unloading plant, and arriving at the furnace are dumped from a series of trestles to the storage yard below, or may be unloaded from gondola cars by McMyler "whirlie" cranes equipped with grab buckets. These cranes also serve to lift the ore from the storage piles and deliver it to drop bottom cars which are transferred over and discharged into the furnace stock bins. Some years ago small amounts of eastern Ontario magnetites were used, but the high sulphur content did not permit of their forming any important percentage of the ore mixture, and their use was discontinued. Latterly, all ores have been secured from the Lake Superior American ranges and from the Helen mine in Michipicoten. Coke is obtained from the Pennsylvania Connellsville district, arriving by way of Niagara Falls, and is dumped direct into the furnace bins or may be stored as required by circumstances. Limestone is obtained from several localities not far from Hamilton. Dolomite from the Dundas quarries is used for the blast furnaces, and from the St. Mary's quarries in Perth and Port Colborne quarries in Welland are obtained the limestones for open hearth work.

The following approximate analyses indicate the quality of the raw material:

Material	Fe	SiO_2	Al_2O_3	P	Mn	CaO	MgO	S	$\frac{Al_2O_3}{Fe_2O_3}$	Ash
Ore	55.00	7.00	2.00	0.25	0.5	0.20	0.10	0 01	....	....
Coke	....	5.-6.	....	0.06	....	0.50	0.30	1.25	5.-6.	10.-12.
Dolomite for blast furnaces	....	1.54	....	....	....	30.31	18.70	....	1.22	....
Limestone for open hearth furnaces	....	0.61	....	....	....	53.75	1.09	....	1.55	....

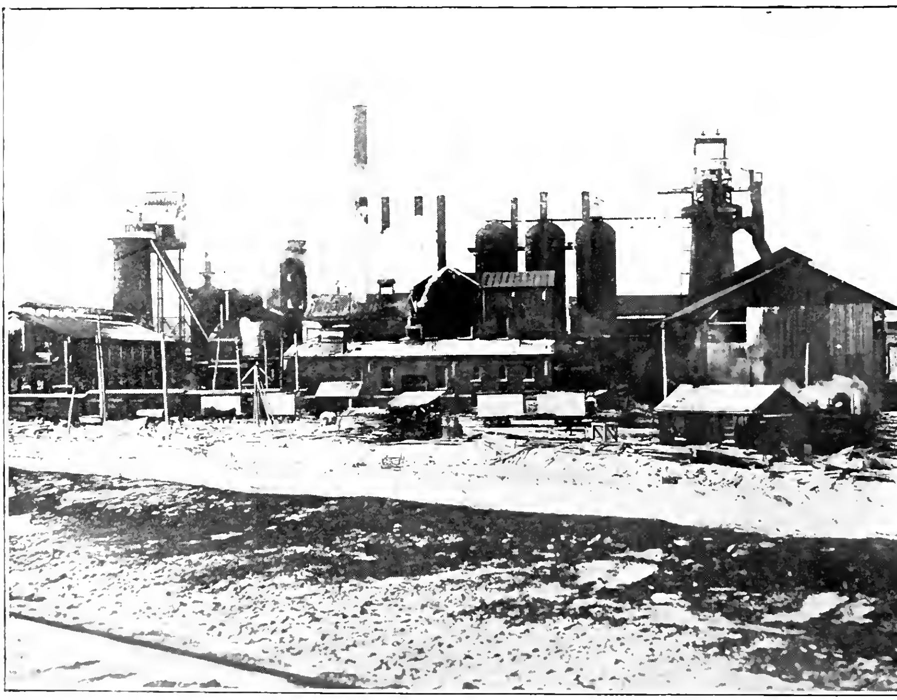
Furnace A

The old original blast furnace, at present blown out, is 75 feet 6 inches high with a bosh diameter of 16 feet, a hearth diameter of 10 feet 3 inches, and 13 feet in diameter at the throat. The hearth is encased in a one-inch steel jacket cooled by water spray on the outside, the boshes being cooled by a series of bronze water blocks. The hearth is pierced for 10 tuyeres, and when in operation the furnace was blown through 5-inch tuyeres with an approximate blast volume of 20,000 cubic feet of air per minute. The furnace is at present equipped with a vertical double cage hoist, all stock being hand filled to a single bell, operated by steam. The charge consisted of about 1.5 lb. of ore per pound of coke for foundry iron, and 1.85 lb. of ore per pound of coke for basic iron, the coke charge weighing 7,000 pounds. The cast house in front of the furnace is a large brick building with ample capacity for sand casting, although the general practice was to convey the hot metal in 22-ton ladles direct to the steel department. The slag was also handled hot, being conveyed to the dump in ladles and used for filling purposes. The stove plant for this furnace consists of three Gordon chimney top, three pass stoves, and one 70 feet x 20 feet Cowper-Roberts stove. The furnace produced on an average 200 tons of iron per day, and when re-

constructed on plans already completed, will, it is expected, increase this amount by 50 tons in 24 hours. The alterations will consist of raising the hearth about two feet, thus shortening the bosh a similar amount, the bosh diameter remaining the same. The throat diameter will be narrowed to 11 feet 6 inches, giving the stack considerably more release per running foot, which will admit of more rapid driving, and the old vertical hoist will be replaced by a double skipway, provided with all necessary charging gear.

Furnace B

The new furnace B. is built on a line with the old stack and has a height of 80 feet over all, the bosh diameter being 20 feet and the hearth diameter 13 feet 6 inches, with 14 feet diameter at the throat. The steel shell, of which the bottom



Hamilton Steel and Iron Company blast furnace plant. Old No. 1 furnace on the left; New No. 2 furnace on the right.

and top plates are ½-inch with the intervening plates ⅜-inch thick, is carried on 8 massive cast iron columns. The bosh is provided with 7 rows of bronze water cooling plates of the Scott type, a single row of these plates being fitted in the hearth brick below the tuyeres. The hearth is jacketted with wrought steel one inch thick, cooled by water spray on the outside, and is pierced for 12 tuyeres. The volume of blast used at present is about 27,000 cubic feet per minute, blown through 5½-inch tuyeres at a pressure of 12 pounds. Under hard driving this volume may be increased to 35,000 cubic feet per minute, with an increase in pressure of 2 to 3 pounds per square inch. For foundry iron the furnace is burdened with about 1.75 lb. of ore per pound of fuel, on a coke charge of 10,000 pounds, the yield of pig metal from the ore mixture averaging 52 per cent.

The furnace is provided with a double skip hoist charging apparatus and distributor of the Roberts revolving type; the distributor, operated electrically, is turned

through angles of 90 degrees for successive skip loads. The large and small bells, of 10 and 4 feet diameter respectively, are provided with a heavy bridge for charging purposes, both bells being operated by steam, The skips are operated by a Crane steam engine. The starting lever for this engine, the control of the bell cylinders, the indicators, distributor, and automatic try rod apparatus are all located at the foot of the skip hoist, and operated by one man.

The bin system behind the furnace consists of two rows each containing six pockets, with a railroad track over each row. The row next to the furnace is used

Hamilton Steel and Iron Company. No. 2 blast furnace during construction, showing Roberts dust catcher.

for limestone and special ores, the two pockets adjacent to the skips being used for coke. The row of pockets on the back side of the stock house is reserved for the main supply of ore. The coke pockets discharge directly into the skip cars by means of chutes provided with screens for getting rid of the "breeze" (fine coke). The ore and limestone are conveyed from the pockets to the skip car by an electric transfer scale car. The gates on all the ore and stone pockets are of pivotted type, and are opened by a lever carried by the transfer car.

The furnace downcomer is connected to the stack at one point, both the furnace and the downcomer being provided with suitable bleeders and explosion doors. At the foot of the downcomer is located the dust catcher, connecting to a Roberts cen-

trifugal dust collector,[33] with a by-pass around the dust collector to the gas mains which lead to the hot blast stoves and boilers. The gas mains are equipped with seven dust legs closed by counter-weighted bells. The whole system for cleaning the gas is giving efficient service, very little dust finding its way to the stoves or boilers.

The three hot blast stoves are of the Roberts-Cowper type 21 feet in diameter and 90 feet high. These stoves are capable of heating the blast to 1,600 degrees F., although ordinarily the temperature is not over 1,200 degrees. Both hot blast and chimney valves are water cooled, the chimney gases escaping to a steel stack 160 feet high and 8 feet in diameter, provided for the stove system of both furnaces. The pyrometers for indicating the temperatures of the blast and the pressure gauges for blast pressure are of the Bristol electric recording type, and are situated in the office of the furnace superintendent.

The cast house consisting of a steel frame covered with corrugated iron is 55 feet wide by 235 feet long and is provided with sliding doors on the sides. The iron is cast in sand pig beds or may be taken in hot metal ladles to the steel department, depending on whether the furnace is on foundry or basic iron. An overhead electric crane of 10 tons capacity runs the full length of the cast house, and conveys the pig combs (beds) to a Brown hydraulic pig breaker placed at the lower end of the house. The iron as it is broken drops into chutes that deliver to railroad cars for shipment.

The new furnace was designed and constructed under the supervision of The Frank C. Roberts Engineering Company of Philadelphia, the furnace lines being supplied by Charles A. Grimes, superintendent of blast furnaces for the Hamilton Steel and Iron Company, Limited. The furnace was expected to produce 300 tons per diem, and since it has been in blast has turned out an average of 325 tons of 2.5 per cent. silicon iron per 24 hours, on a fuel consumption of about 2,600 pounds per long ton of iron. This practice speaks for itself, and is commendable alike of the builders and of the operating management.

Approximate analyses of iron produced from furnace B. are as follows:—

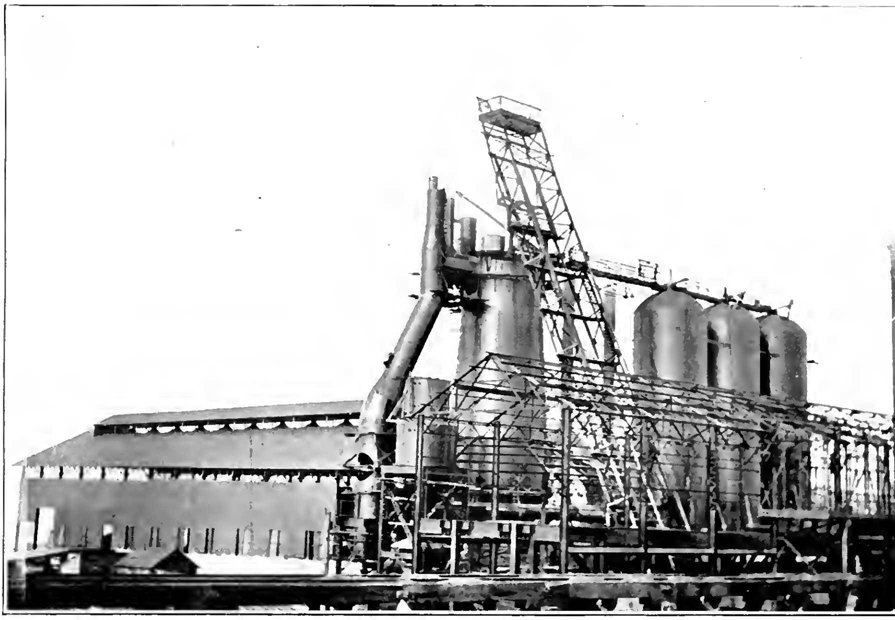
Grade	Si.	S.	P.	Mn.	G. C.	C. C.
Foundry Iron	2.50	0.020	0.50-0.60	0.4-0.6	3.0-3.25	0.5
Basic Iron	1.25	0.050	1.0-2.0	1.0-1.5	....	....
Malleable Bessemer	1.25	0.025	0.15-0.2	0.6	....	....

The power plant is common to both furnaces and consists of 10 Sterling and two Babcock and Wilcox boilers, combined capacity 3,600-h.p. All boilers are arranged for both gas and coal firing, and are provided with independent stacks. The engine house contains 5 blowing engines, two Gordon engines, 42-inch steam, 84-inch air, and 60-inch stroke, one Laurie engine, 42-inch steam, 84-inch air, and 60-inch stroke, and two Todd engines arranged to work cross compound, the high and low pressure steam cylinders being respectively 42 inches and 82 inches, and the air cylinders 84 inches in diameter with a 60-inch stroke. The installation of a sixth engine is contemplated for the near future. The pumping equipment consists of three electrical turbine pumps and one direct acting plunger pump, having a total capacity of 12,000,000 gallons in 24 hours. The electrical generators are three machines with an ample capacity to meet all ordinary requirements.

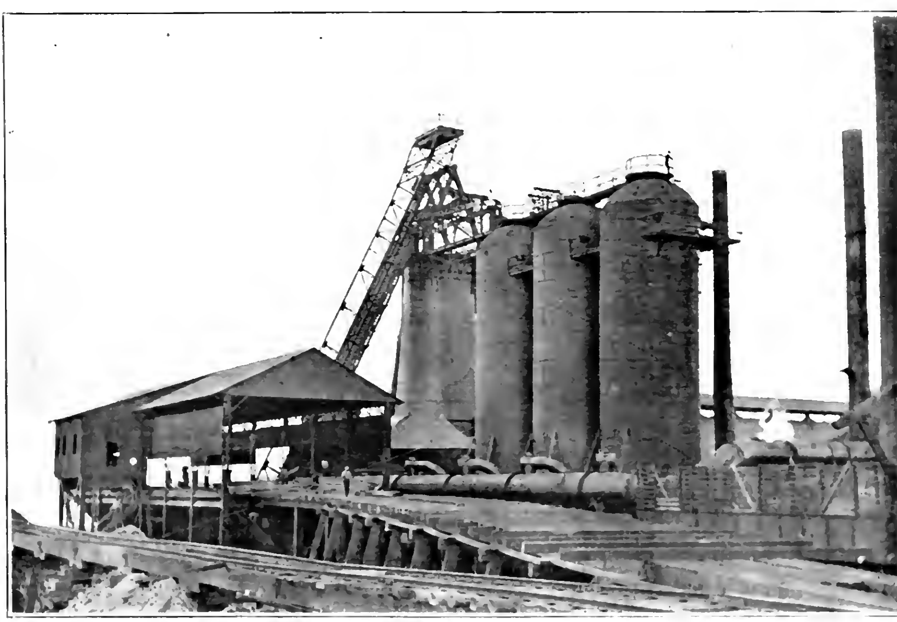
The Steel Department

The basic open hearth department is contained in a steel and corrugated iron building 400 feet long by 90 feet wide, situated about 300 yards from the blast furnaces. This building also contains a newly installed hot metal mixer of 150 tons capacity, heated by natural gas and geared to a 25-h.p. electric motor for tilting pur-

[33] See Iron Age, May 9, 1907, for description of this dust collector.



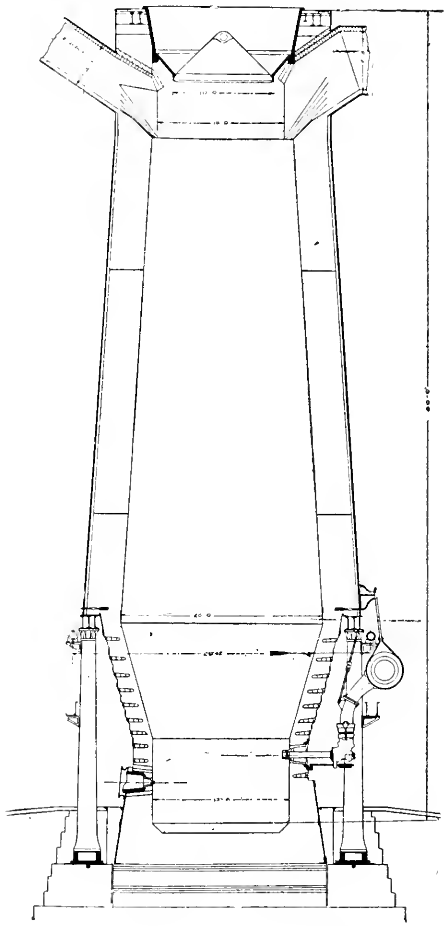
Hamilton Steel and Iron Company. No. 2 Blast furnace during construction.



Hamilton Steel and Iron Company. No. 2 blast furnace during construction.

poses. A small steel foundry is included in the equipment, manufacturing steel castings and forging blooms. About 100 tons of various kinds of castings are produced monthly.

Two of the open hearth furnaces are of 40 tons and two of 20 tons capacity; all are of the stationary type and are fired with natural gas piped from the Attercliffe fields in Haldimand county. The gas needing no regeneration enters the furnace through two $2\frac{1}{2}$-inch water-cooled ports at each end of the hearth, at a pressure of 8 ounces per square inch. Two ports at the same end are opened together. The gas



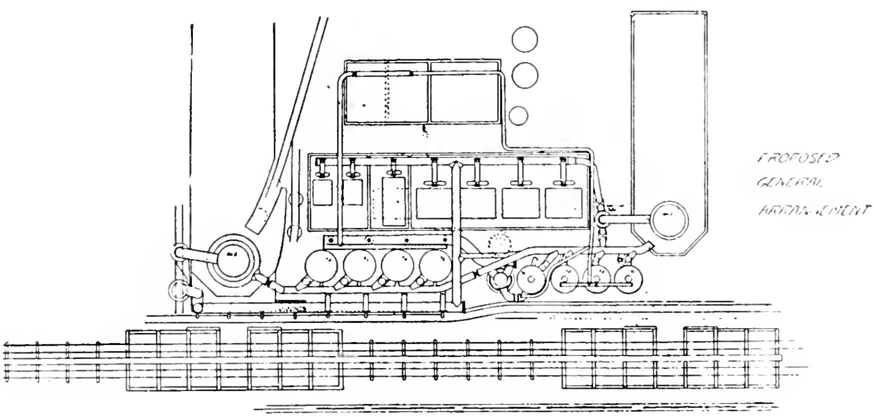
Hamilton Steel and Iron Company. Lines of No. 2 blast furnace.

mixed with air that passes up through the regenerators below, sweeps through the furnace, the products of combustion passing through the regenerators at the opposite end. Every 15 minutes the direction of the flow of gas and air is changed by closing the gas and air supply at the cold end and opening the ports at the hot end, the products of combustion passing through the first set of regenerating chambers. In this way the whole regenerating system is used for heating the air, the efficiency of the furnace being increased considerably thereby. Natural gas is easier of control, less hurtful on the furnace and is cheaper than producer gas. The volume of gas con-

sumed in these furnaces per ton of product is about 6,000 feet. A battery of nine 10 x 10-foot water sealed gas producers is installed behind the open hearth department, but is only used as an auxiliary in case the supply of natural gas should prove inadequate.

The stock enters the building by an elevated road on the charging side of the furnaces, being served by a Wellman electric charger of the ordinary type. A normal furnace charge consists of 51 per cent. of hot metal from the mixer with 49 per cent. of scrap, the limestone added being about 10 per cent. of the weight of the metal charged. Ore is charged only in special cases. An average of three heats per furnace is worked in 24 hours. On the casting side the department is equipped with four overhead travelling cranes—one 75-ton Shaw crane with a 10-ton auxiliary carriage, one 40-ton Niles crane, one 20-ton Shaw crane and one 5-ton Whiting crane. The ladle equipment consists of two 50-ton and two 30-ton steel ladles, also four 22-ton hot metal ladles.

The steel is cast in 6-inch ingots weighing about 400 pounds each; these small ingots are necessitated by the fact that there is no blooming mill in the rolling mill department. Casting is accomplished by the bottom plate method, the ingot moulds



Hamilton Steel and Iron Company; proposed general arrangement of blast furnace plant.

standing in groups of 65 on a cast iron circular plate provided with channels well luted with fire clay. The steel is teemed into a central "git" and flowing through the channels in the bottom plate, rises in the ingot moulds filling them simultaneously. About 130 ingots are filled at one cast.

The scrap shears for the cutting up of this material, of which a considerable amount is re-melted, are placed outside of the open hearth building alongside the scrap piles. The largest shear will cut 6 × 6 inches cold; this machine installed lately was supplied by the United Engineering Company of Pittsburg and is driven by a 125-h.p. electric motor. The next size, supplied by the Bertram Engine Works of Dundas, will make a 4 x 4-inch cut and is operated by a 75-h.p. motor. The third and smallest shear making a 2 x 2-inch cut is used for light plate and other small material.

The rolling mill is placed south of and parallel with the open hearth building. This department consists of a continuous heating furnace handling 80 to 90 tons in 12 hours. One 3-high 14-inch train is driven by a 600-h.p. reversing engine, and one 3-high 10-inch train is driven by an 800-h.p. motor. The mill produces about 2,500 tons monthly of merchant bars, flats, rounds, angles and squares. A small spike mill located near by contains two machines which turn out about 15 tons of track spikes daily.

The second rolling mill and the forging plant is located on Queen street, adjacent to the general offices of the company and near the station yards of the Grand Trunk railway. These works include one 2-high 20-inch bar and one 20-inch plate mill, one 3-high 10-inch train, and one 3-high 9-inch muck train, all driven by steam. The furnace equipment consists of four double puddling furnaces, four bushelling furnaces and several heating furnaces. The forge contains 4 steam hammers finishing lathes, etc.

The whole plant at present produces annually 180,000 gross tons of pig iron, 100,000 net tons of steel ingots, and 90,000 to 100,000 gross tons of rolled iron and steel besides forgings, railing car axles and track spikes.

Thanks are due to Mr. Robert Hobson, Vice-President and General Manager of the Company, for courtesies received, and to Mr. George L. Drew, general superintendent, to Mr. Charles A. Grimes, superintendent of blast furnaces, and to Mr. F. B. McKune, superintendent of the steel works, who kindly supplied all information, putting much of their time at the disposal of the writer.

The Canada Iron Furnace Company, Limited

This company has operated a small furnace in Midland, Simcoe county, on the Georgian Bay since 1900, the furnace being first blown in on November 28th of that year.

The plant is situated on the shore of Midland harbor facing the town, the works being erected in immediate proximity to the water. The substantial ore docks are 1,700 feet long with an average depth of water of 22 feet alongside and are equipped with three 60-foot boom, McMyler "whirlie" hoists, running on a railroad track that extends the full length of the docks. Two of these hoists are fitted with 5-ton clam-shell grabs, the third with ordinary hand filled buckets. The ore storage yard between the furnace and the water has a capacity of about 100,000 tons of ore. It is the intention to bridge the dock from end to end, placing the McMyler hoists on the trestle, which will greatly facilititate the unloading of the ore boats and will about double the capacity of the storage yard.

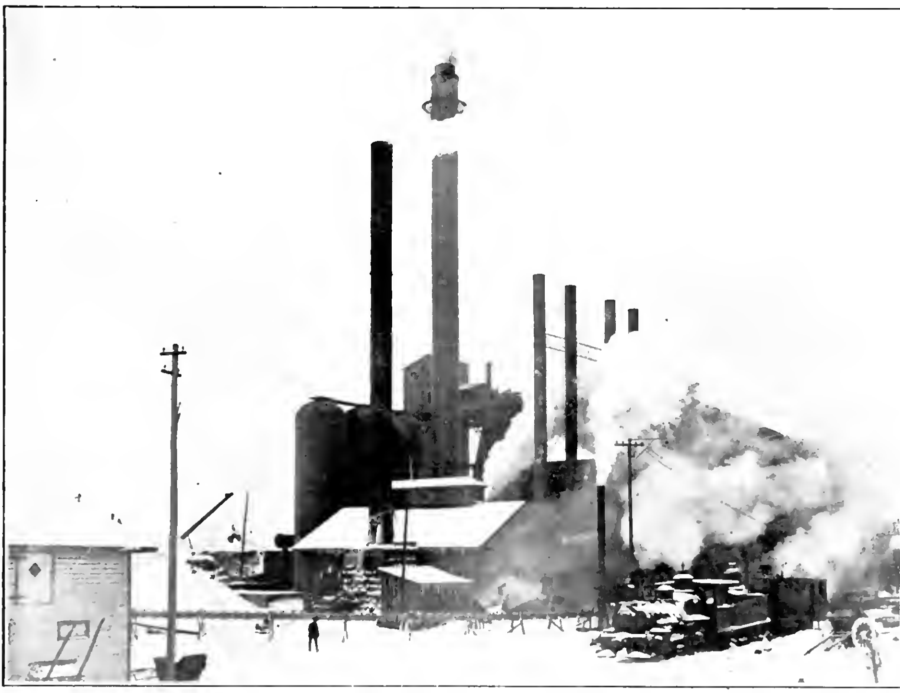
A stock shed behind the furnace contains two 5-beam Howe scales for weighing the coke, ore and limestone, and affords shelter for the stock house gang "between rounds." The ore supply is obtained mainly from the Lake Superior district, the percentage of imported ores used varying between 50 and 75. Considerable amounts of native ore have been smelted from time to time, notably that produced from the Helen mine. Eastern Ontario magnetites have also received their share of attention, but as at other furnace plants, the ores have generally proved too high in sulphur. However, within the past two years a considerable amount of magnetite from The Mineral Range Iron Mining Company in Hastings county has been received by rail and successfully worked, and no doubt this ore, if holding its present quality, will be used in increasing amounts in the future. Coke is brought in entirely by rail from the Connellsville district in Penslyvania,, and is stored in large open piles, or may be used direct as required. The limestone is obtained from the company's quarries on the eastern shore of Midland bay, about five miles from the furnace and is conveyed on scows towed by steam tug to the plant where it is unloaded by the McMyler cranes. Several shipments of limestone have also been received from the Longford quarries north of Orillia.

Approximate analyses of the ore, coke and limestone are as follows:—

Material	Fe	SiO_2	Al_2O_3	P	Mn	Ca O	Mg O	S	Ash
Ore	52.5	8.-10	1.25-3.0	.015-.61	.08-3.6	0.20-9.15	0.10-3.03	.006-.14	....
Coke	2.86	6 16	2.57	0.013	....	0.40	0.26	1.26	10.0-12.0
Limestone	0.69	3.96	0.32	0.10	....	39 25	10.85	0.097	....

The Blast Furnace

The furnace, 64 feet 6 inches high, 13 feet in diameter at the bosh, with 8 foot 6 inches hearth and 10-foot throat diameter, is located with its back to the docks and is hand filled, the stock being hoisted in buggies by a double cage elevator controlled by an automatic Crane steam engine. The furnace shell is carried by 8 cast iron columns resting on a granite faced, concrete foundation 32 feet square at its base and 24 feet square at the top. The hearth, protected by three-inch cast iron jackets fitted with interior pipe water coils, is pierced for 8 tuyeres, the bosh being cooled in the same way as the hearth with cast iron water coil jackets. The downcomer is connected with the furnace through a short tunnel head, and is provided with suitable explosion doors and a single bleeder. A cylindrical dust catcher of the ordinary type is placed at the foot of the downcomer, the gas after passing the dust catcher being conveyed to the hot blast stoves and boilers through large mains provided with dust legs.



Canada Iron Furnace Company, Midland. View of blast furnace.

The hot blast equipment consists of three Foot stoves, 60 feet high and 16 feet in diameter, of the two-pass type, erected in line on a granite faced concrete foundation 60 feet long and 27 feet wide. The stoves are provided with water-cooled hot blast and chimney valves, and are capable of heating the blast to about 1,400 degrees F. The foundation for a fourth stove 75 × 19 feet is in place, and when this additional unit is constructed it will add materially to the efficiency of the system. The steel draft stack for the stoves, 174 feet high and 8 feet 6 inches in diameter, is carried on a massive concrete base 26 feet square at the bottom and 20 feet square at the top, standing 21 feet high and faced with granite. The stack is lined with fire brick and is provided with a vertical outside ladderway extending to a small circular platform at the top.

The three blowing engines are installed in a solid brick building 67 feet 6 inches long by 40 feet wide and 48 feet high. Two of the engines installed at the time the plant was under construction, were manufactured by The Columbus Machine Company of Ohio; they are vertical high pressure Corliss engines with 36-inch steam cylinders, 72-inch air cylinders and 48-inch stroke. The third installed during 1906 is a Mackintosh and Hemphill vertical high pressure engine with 34-inch steam, 72-inch air and 48-inch stroke. Both the air inlet and discharge valves of all three engines are of the ordinary gridiron type. At 26 revolutions the three engines combined will deliver about 17,600 cubic feet of air per minute. The pumping machinery for furnace and stove circulation, also for fire purposes, consists of two Gordon Duplex pumps 16 x 10 x 12 inches; for boiler feed purposes, there are one Gordon Duplex 8 x 5 x 6 inches and one Worthington pump 10 x 5 x 10 inches. A steel water tank 12 feet in diameter and 40 feet high, holding 28,000 gallons is installed on a hill behind the furnace 72 feet above the level of the bay, but is only drawn on in case of emergency. The electric light plant consists of a 25-kilowatt generator connected with a 9 x 10-inch engine, this equipment having ample capacity to meet requirements.

The boilers are installed in two brick buildings, the largest of which adjoins the engine room and contains four 250-h.p. McDougal return tubular boilers fired with furnace gas which enters the boiler room through an overhead main. In the smaller building alongside are placed two additional McDougal boilers of 150-h.p. each, also fired with furnace gas. All boilers have separate stacks, the whole installation developing 1,300 horse power and delivering steam to the engine room at 125 pounds pressure. Coal is used for auxiliary firing, but very little is consumed.

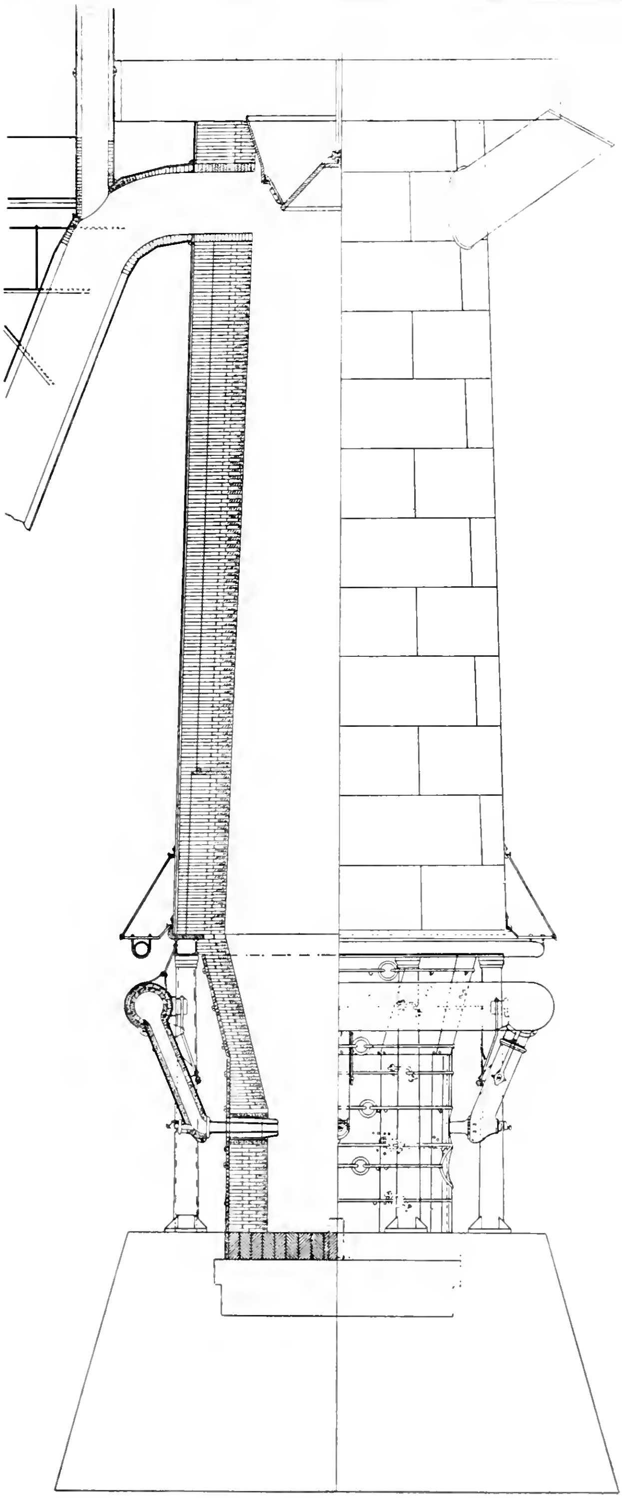
The cast house in front of the furnace is built of brick with heavy wall pilasters, and is 165 feet long by 40 feet wide. The walls are erected on solid concrete foundations faced with granite, and are provided with large sliding doors to facilitate the removal of the pig iron and scrap. The roof is constructed of steel and wood, covered with fire proof cement. All the iron is cast in sand moulds, the pig beds being 5 feet above the yard level, and after being cooled and broken the iron is thrown on cradles suspended from an overhead trolley and conveyed through the end doors of the house to a transfer platform where it is loaded direct in cars for shipment, or may be taken to the iron storage yard. During the open season of navigation a large amount of bessemer iron is shipped by boat to The Algoma Steel Company, the iron cars as they are loaded at the furnace being transferred to the dock and the boats loaded by means of the McMyler cranes.

Slag is handled hot in two 10-ton Dewhurst slag ladles,—one side-dump and one end-dump,—and is conveyed to the outskirts of the yard where it is used for filling purposes. The ladles are provided with interchangeable thimbles of cast iron, and when dumped the skull of congealed cinder falls out itself, doing away with the necessity of cleaning the ladles.

About 17,500 cubic feet of air per minute is delivered to the furnace through eight 5½-inch tuyeres at 6½ to 7½ pounds pressure per square inch, the blast temperature averaging 1,100 F. The furnace makes on an average 115 tons of bessemer iron daily, on a fuel consumption of 2,800 lb. of coke per gross ton of pig, from an ore mixture yielding practically 48 to 50 per cent. of pig iron. The charge is made up as follows:—

Coke	6,000	pounds
Ore	9,200	"
Dust	600	"
Mixed scrap	500	"
Limestone, average	3,500	"

From 5 to 10 per cent. of the ore charge is blown out on top and after being thoroughly wetted down this dust is recharged in small amounts, forming a constant item on the charging sheet. When running on Bessemer iron, the slags made will



Canada Iron Furnace Company. Lines of blast furnace.

average 34.5 per cent. silica with 9.5 to 10.5 per cent. of alumina. On foundry iron the silica is reduced 1 to 2 per cent., and the alumina increased a correspondingly approximate amount.

The following is a list of actual analyses of the Bessemer iron made in one day's run:

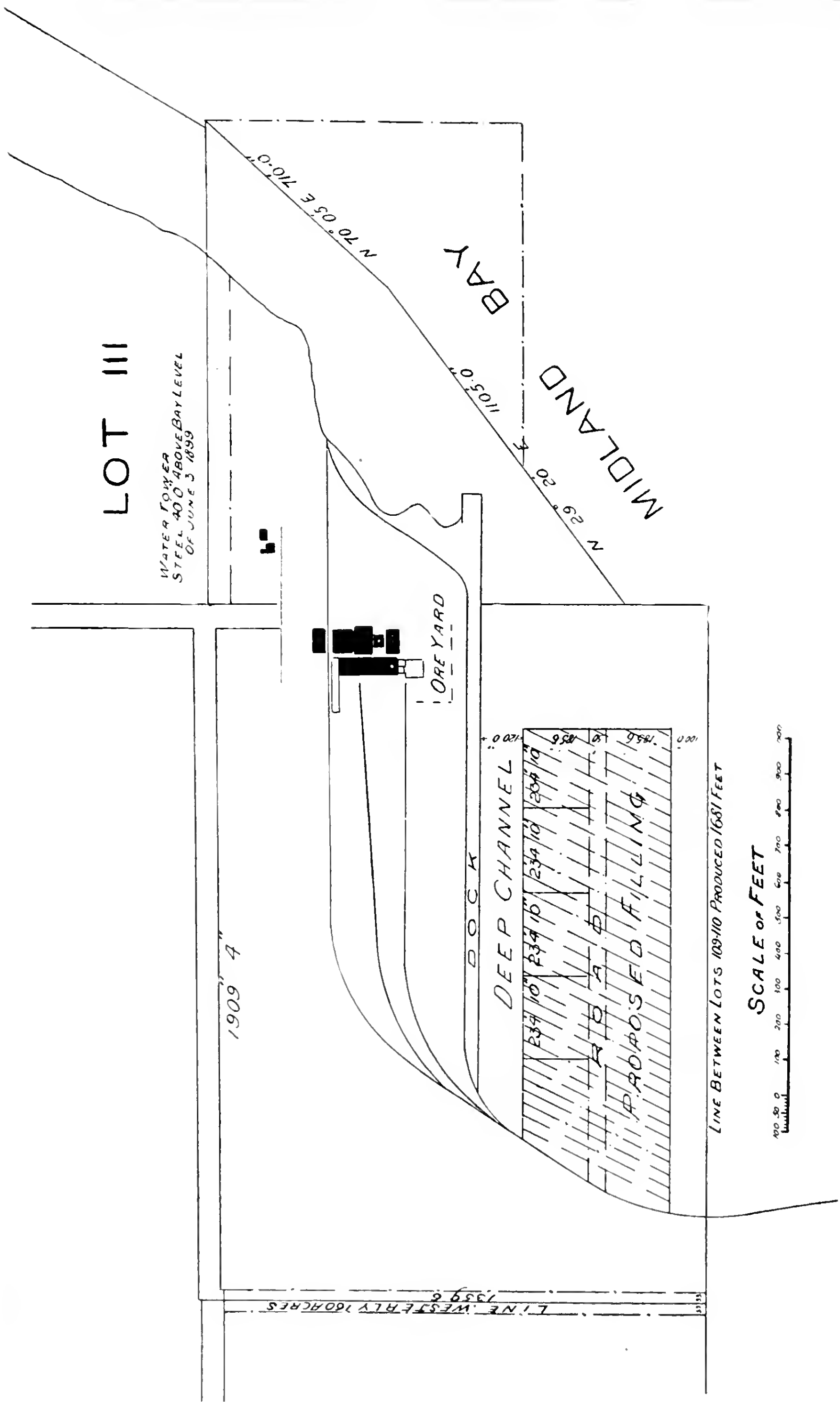
Si	S	Phos	Mn
1.04	0.041	....	....
1.08	0.034	....	....
1.11	0.029	0.088	0.68
0.98	0.039	....	....
1.04	0.041	....	....
1.32	0.039	....	....

Canada Iron Furnace Company. Flushing off slag into ladle.

Foundry iron will average from 2 to 3 per cent. silicon, 0.025 per cent. sulphur, 0.8 per cent. phosphorus, and about 0.6 per cent. manganese.

A machine shop and blacksmith forge are located in a 60 x 30-foot brick building at one side of the engine house, and contain all necessary tools for repair and other work. Adjoining the machine shop is a small building with the grinding and sampling apparatus for ores and cokes. A small electro-magnetic separator of the drum type is operated alongside the machine shop. This machine is used for saving the shot iron in the sand riddlings from the cast house, and has proved of considerable value in this capacity.

A large brick chemical laboratory 30 x 40 feet, situated some distance from the furnace to be free of dust and vibration, is one of the features of the plant. The building is divided into three rooms, the laboratory proper, the scale room, and the office, and is completely equipped in every detail for rapid and accurate analytical work. Two chemists are employed, one for day and one for night turn.



Canada Iron Furnace Company. General plan of works.

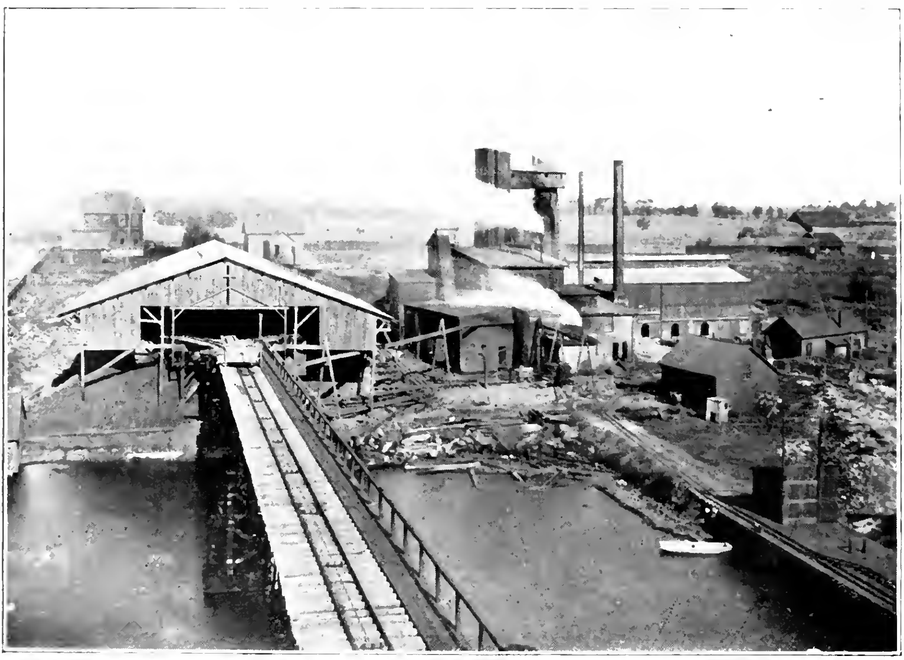
It is the intention of the company to build a second blast furnace with a capacity of 200 tons per day in the near future. This new stack, it is expected, will be about 75 or 80 feet high with an 18-foot bosh and 10 or 12-foot hearth, and will be equipped with a modern skip hoist and charging gear. The iron will be cast in sand and handled by an overhead crane carrying the combs to an hydraulic pig breaker.

The plans for this additional unit are prepared and but for existing conditions in the general iron market, construction would now be under way.

To Mr. George D. Drummond, superintendent of the plant, I am indebted for all of the above information, and I take this opportunity of expressing my thanks.

The Deseronto Iron Company, Limited

The Deseronto furnace is excellently situated about half a mile south of the town on the shore of the bay of Quinté. The plant was constructed during 1898, and



Deseronto Iron Company, Deseronto. View of blast furnace from ore docks.

on January 25th, 1899, was blown in with charcoal as fuel. The use of charcoal was continued until the end of 1906, when the Standard Chemical Company, Limited, also of Deseronto, manufacturers of charcoal and its by-products, found it extremely difficult to obtain cordwood at reasonable prices and had to abandon its contract with the furnace, which accordingly was blown out. It was then decided to manufacture coke iron, and after making general repairs on the plant all round, and increasing the furnace bosh a foot in diameter, another campaign was started on September 16th, 1907.

The fuel arrives by rail from the Connellsville district in Pennsylvania. This coke is of special low sulphur content, as the furnace (modelled on charcoal lines) is not adapted for the efficient removal of that element. The coke is shipped in hopper bottom steel cars and arriving at the plant, is forked into the charging buggies, or may be dumped from a trestle on stock piles alongside the furnace.

The ores are obtained chiefly from the American Lake Superior ranges, arriving via the Welland canal, and are unloaded at a 500-foot trestle dock 35 feet high extending outwards at right angles to the shore line. This trestle with 16 feet of water alongside, is provided with a McMyler hoisting drum operating three unloading whips equipped with ordinary hand filled buckets. The loaded buckets are dumped into a chute delivering to 6-ton cars, which run by gravity down the dock trestle to the ore bins, and after being dumped are returned with the assistance of a counterweight suspended at the water end of the trestle. The unloading plant as it stands has a capacity of 100 tons per hour. Attempts were made at various times to utilize the magnetites from Belmont, Blairton and other localities along the Central Ontario railway, but owing to the percentage of sulphur contained in these ores, shipments were few and far between. However, the opening up of the deposits at Bessemer controlled by The Mineral Range Iron Mining Company afforded further opportunity of utilizing native ore, and in consequence some shipments from these mines have been received.

Limestone obtained from cuttings along the Bay of Quinté railway between Strathcona and Yarker, is crushed at the furnace to about 2½-inch size by a 10 x 22-inch Blake crusher, driven by a 25-h.p. engine; the crushed stone is then elevated by a bucket conveyor to storage bins in the stock house and may be chuted into the charging buggies as required.

Approximate analyses of the ores, coke and limestone used by the company are given:

Material.	Fe	SiO_2	Al_2O_3	P	Mn	CaO	MgO	S	Ash	Fixed Carb.
Ore	51.-59.	8.-22.	0.68-2.0	0.05-0.5	0.07-0.92	0.22-3.25	0.17-3.17	0.001-.08	....	....
Coke	....	5.43	2.94	0.013	....	....	....	0.80	10.00	89.51
Limestone	....	3.97	1.91	0.002	....	91.44 ($CaCO_3$)	3.50 ($MgCO_3$)	0.078	....	....

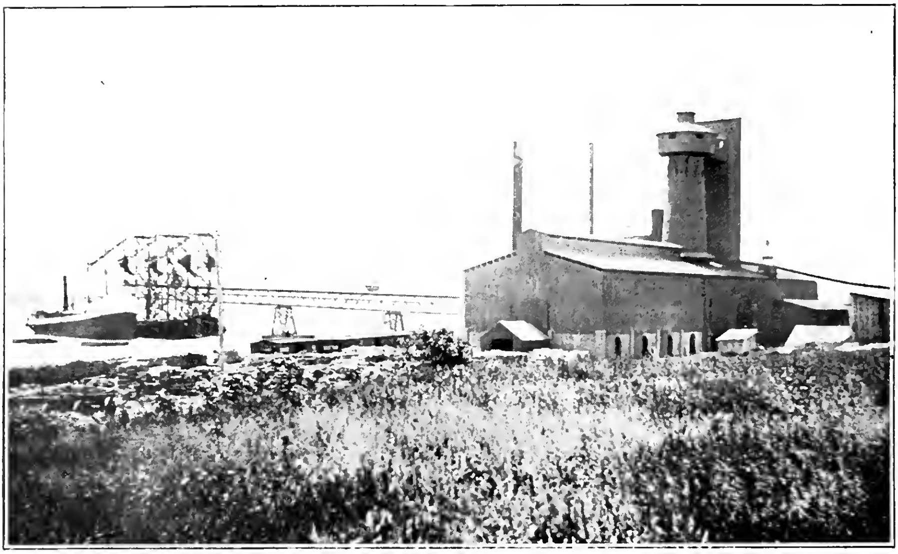
The Blast Furnace

The furnace is 61 feet high over all with a 10-foot 6 inch bosh diameter and a hearth diameter of 6 feet 5 inches. The steel shell is carried on a cast iron mantle supported by 8 iron columns, both bosh and hearth being protected by ½-inch steel jackets cooled by outside water sprays. The hearth is pierced for 7 tuyeres. At the time of my visit 3-inch tuyeres were being used, the volume of blast, averaging 8,000 cubic feet per minute at about 6½ pounds pressure per square inch. The furnace is equipped with a 40-inch downcomer attached at one point and leading to a cylindrical dust catcher of the ordinary type, tapped by the stove and boiler gas mains.

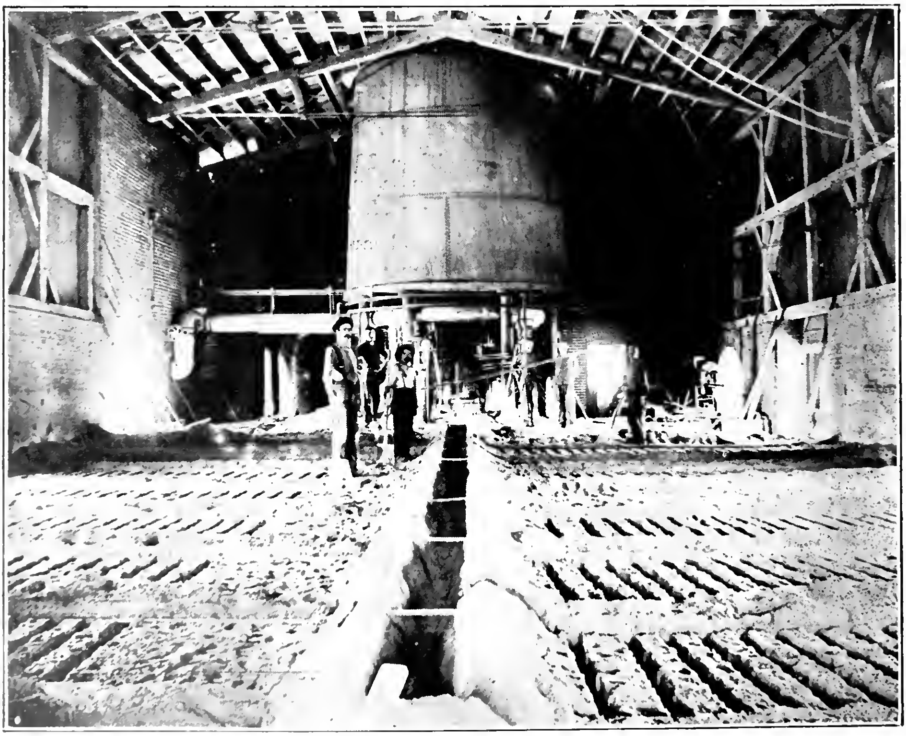
The hot blast equipment consists of two ordinary charcoal iron pipe stoves, each stove holding 36 U pipes, 9 feet high and 5 × 8 inches in section. This system will heat the blast to only 750 degrees F., which is found to be a serious drawback in operating the furnace with coke fuel.

The blast is supplied by a vertical blowing engine, 42-inch steam cylinder, 84-inch air cylinder and 4-foot stroke, made by The Columbus Machine Company. The pumping equipment consists of one 12 x 7 x 12-inch plunger pump on the dock, and one 6 x 10 x 6-inch pump in the boiler room, both pumping to an elevated tank, which supplies the water for furnace circulation and is also connected to two boiler feed pumps. The electric light for the plant and office building is generated by a Junior Westinghouse machine belt driven from a 15-h.p. vertical Westinghouse engine.

The boiler house adjoining the engine room contains four ordinary return tubular boilers of 75-h.p. each, supplying the engine room with steam at 85 pounds pressure.



Deseronto Iron Company. General view of works, showing ore unloading docks.



Deseronto Iron Company. Interior of cast house.

The furnace is hand filled, stock being hoisted by a pair of vertical elevators, belt driven from a horizontal engine through line shafting, with fast and loose pulleys. The ore bins, of which there are seven, are located in a wooden building 206 feet long by 90 feet wide, extending shorewards from the ore docks. The bins have a total capacity of 18,000 tons, and are connected to the furnace elevators by the C. W. Hunt system of narrow gauge track. The charging buggies running on this track will hold about 800 pounds of ore and are trammed from the bins to the furnace weigh scales, then elevated to the top and dumped.

The iron is cast in sand beds in front of the furnace, the cast house being 98 x 43 feet in plan. After the pigs are cooled and broken, they are conveyed in wheelbarrows to the grading platform, each bed being graded separately, and they are then shipped direct or piled in the storage yard. Before the iron leaves the cast house, two samples are taken from each bed and combined, the combined samples from one bed being added to the samples of the next, making one average sample for every two beds: thus if there are 6 beds there will be three final samples, full analyses being made on each final sample. This method of sampling, although laborious gives very accurate analyses of each cast, and is satisfactory alike to the company and to the customer.

Analyses of iron made by the Deseronto company are as follows:

Grade.	Si	S	P.	Mn	G.C.	C.C.
Foundry	2.54	0.022	0.37	0.537	3.03	0.27
Malleable Bessemer	1.77	0.035	0.13	0.416	3.12	....

Foundry Iron is graded by analysis as follows:—

Grade	No. I, soft	No. I, X	No. I	No. II	No. III
Silicon	3.10-2.80	2.80-2.50	2.50-2.20	2.20-2.00	2.00-1.75

The maximum limit for sulphur in foundry or malleable Bessemer is 0.05 per cent.

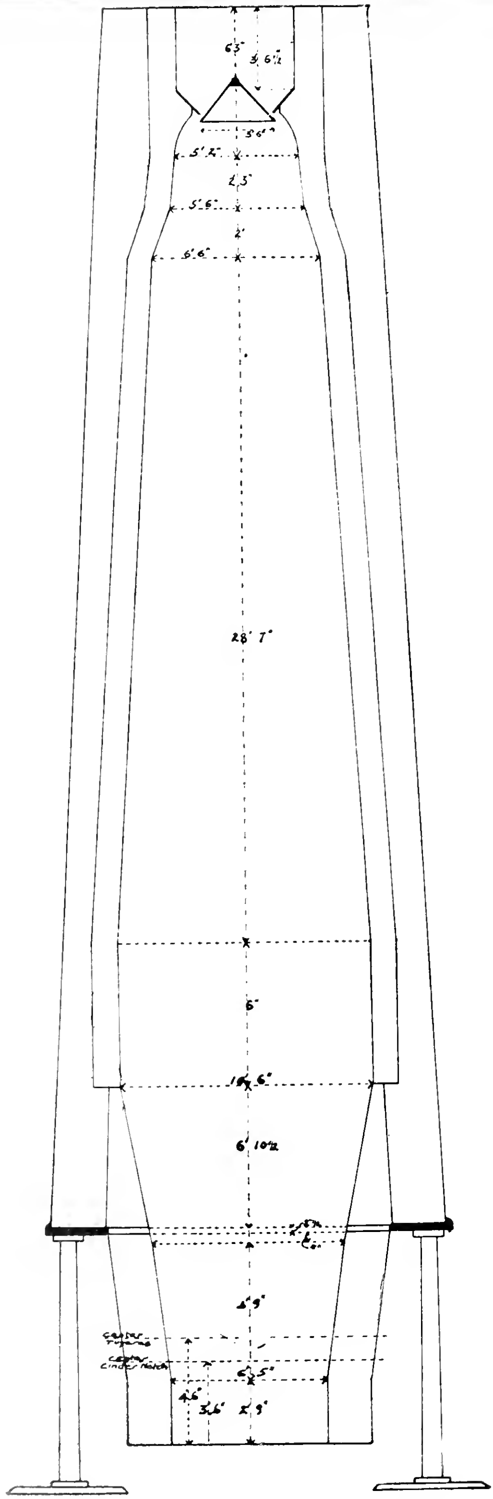
The slag made during recent coke practice is very basic, and will air slack readily. The idea of operating the furnace on this character of slag is to maintain sufficient heat in the smelting zone, by the high formation temperature of this cinder, the heat and basicity of the slag combining to eliminate sulphur. The slag is allowed to run from the furnace into circular holes in the slag yard, these holes being provided with a central iron rod terminating in a ring; and after the cinder has set, the blocks are picked up by a hand winch crane, transferred to carts and taken to the dump, the iron rods being removed for future use, as the blocks are broken.

About 35 gross tons of iron are made daily on a coke consumption that has averaged above 3,000 pounds of fuel per ton of product. This excessive consumption of fuel is due to the fact that the furnace is hardly of sufficient height for coke practice, and the hot blast installation will not permit of carrying the necessary temperature required for burning coke fuel. This want of balance in the equipment is illustrated by the fact that not more than 1.2 pounds of ore is carried per pound of coke, on a fuel charge of 6,000 pounds.

The plant, although small, has the reputation for turning out an excellent brand of pig, the charcoal iron made in former years always commanding the maximum market price, and being of special value in the manufacture of chilled car wheels.

The works are under the general superintendence of Mr. F. B. Gaylord, to whom thanks are due for all information and courtesies received at the time of my visit.[34]

[34] The Deseronto furnace went out of blast about the middle of March, 1908, and will remain inactive until there is a decided improvement in the general condition of the iron market.

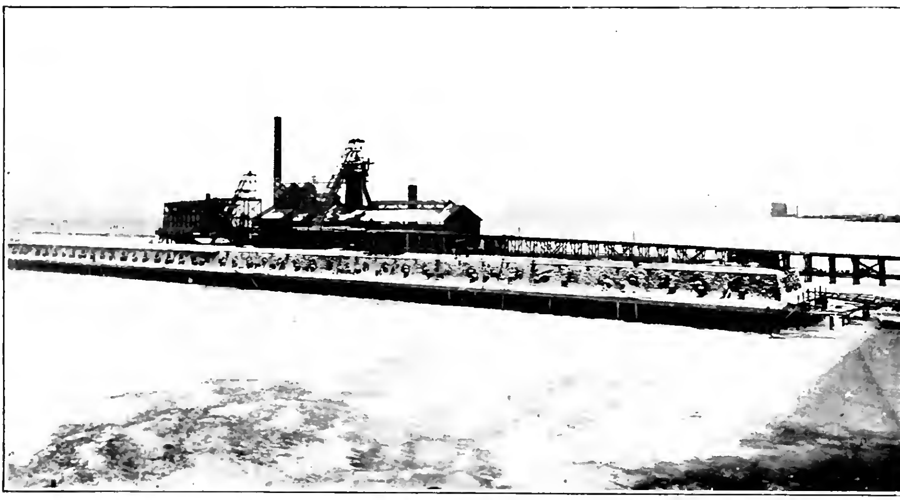


Deseronto Iron Co. Blast furnace lines.

The Atikokan Iron Company, Limited

Of late years considerable attention has been given to the deposits of iron ores that are found in the Thunder Bay and Rainy River districts of northwestern Ontario. Various projects were put forward for the utilization of these ores, but it remained for The Atikokan Iron Company, Limited, organized in 1905, to demonstrate the practicability of roasting and smelting the high sulphur magnetites of the Atikokan range for the production of foundry iron.

The furnace plant of this company is located on the western extremity of the town of Port Arthur and is built fronting the shore line of Thunder Bay. Considerable difficulty was experienced in securing proper foundations, as the ground was low and swampy, necessitating the driving of hundreds of 22-foot piles which were afterwards capped with re-inforced concrete. The Company's property has a lake frontage of 1,800 feet with a depth of 3,000 feet, which is mostly muskeg and will be filled in with furnace slag, granulated for the express purpose of yard making.



Atikokan Iron Company, Port Arthur, Ont. General view of works.

Construction was started in 1906, the furnace being blown in on July 17th, 1907, and continuing in blast until the 14th of December in the same year, when owing to the unfortunate condition of the iron market, the works and mines were closed down until the outlook improved for a more profitable disposal of the product.

Roasting the Ore

The plant comprises a blast furnace with all modern improvements in the way of stock handling apparatus, an ore roaster operated by the blast furnace gas, and a battery of 100 beehive coke ovens.

The ore arrives in 50-ton drop bottom steel cars from the mines 131 miles southwest of Port Arthur on the Canadian Northern railway, and is discharged from a trestle to stock piles, or may be dumped direct to the bins feeding the roaster skip car. A McMyler hoist equipped with an orange-peel grab bucket serves to load the stock ore into cars, which are transferred over and discharged into the roaster skip bin.

The type of roaster adopted is the same as that in use at the Wiarton Furnaces, New Jersey, the Lebanon furnaces of the Pennsylvania Steel Company and the English plants of Bolckow, Vaughan and Company, Limited, Middlesbrough, and the Frod-

ringham Iron and Steel Company, Limited. As the fuel used is the waste furnace gases, economical engines, pumps, etc., are necessary in order to save fuel at the power plant. The roaster is carried on steel legs supported by solid concrete foundations, and is divided into 16 sections each containing separate combustion, roasting and chimney

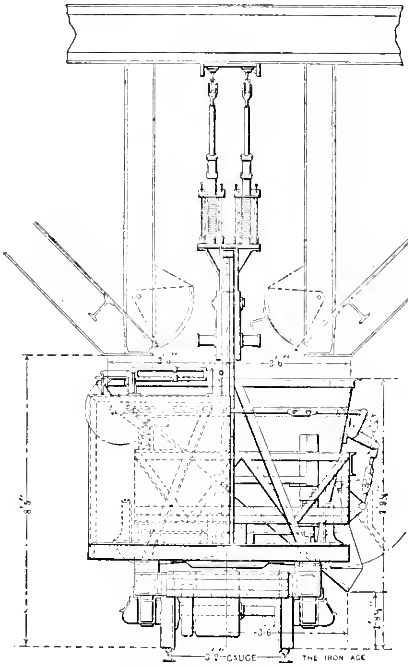


Fig. 5.—End View of Stock Transfer Weigh Car.

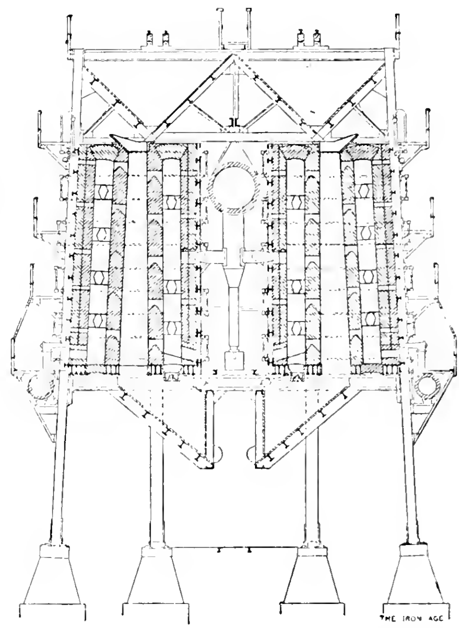


Fig. 4.—Sectional Elevation of the Ore Roasting Kilns, Showing Arrangement of Chambers.

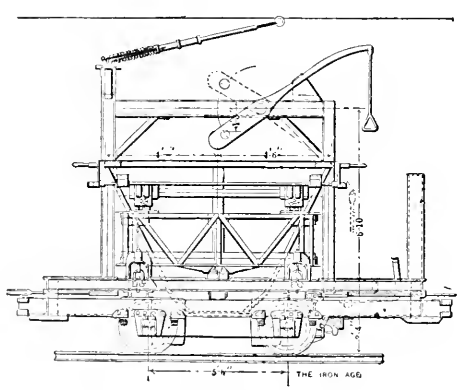


Fig. 6.—Side View of Transfer Car, Showing Lever for Opening Bin Chutes.

Atikokan Iron Company. Ore roaster and stock transfer weigh car.

chambers, the products of combustion passing through the ore to the chimney chambers where they are drawn by two Sturtevant 12-foot exhaust fans into a chimney. The draft, being controlled mechanically, admits of adjusting the supply of air according as the ore is fine or coarse, coarse ore requiring less air than the fine material.

The ore is elevated to the top of the roaster by means of a steam skip hoist discharging into an automatic railroad truck of the Mead-Morrison type, and is thence transferred to the roaster bins from which it feeds itself into the roasting chambers. The hot gases permeating the mass of ore heat it up to about 1,500 degrees F., driving off the sulphur, and as the action is one of oxidation converting the magnetic oxide to the peroxide form, corresponding to hematite, this change is beneficial in subsequent smelting operations. The ore remains in the roaster 24 hours, each chamber holding 25 tons, and the sulphur is reduced from an average of 2.5 per cent. in the raw ore to an average of 0.75 per cent. in the roasted product. The roasting chambers discharge into bins provided at their bottom, the ore being delivered therefrom into an electrically operated stock transfer scale car, which conveys the roasted ore to the furnace skip cars. Provision is also made so that the roasted ore may be delivered into ordinary railroad cars for shipment, the roaster being designed to permit of additional units being added later if required, and the present hoisting equipment being of ample capacity to meet any requirements in this direction.

Limestone is obtained from Kelly island in lake Erie, favorable rates being secured on ore freighters which would otherwise return empty to the head of Lake Superior from lower lake ports. The stone is unloaded at the Company's dock by 50-foot boom McMyler hoists equipped with orange-peel grabs, and is transferred to the furnace siding in drop bottom steel cars.

Coal for the coke oven plant is obtained from the New River and Crescent fields in West Virginia, transferred to boats at Lake Erie ports, and unloaded in Port Arthur at the coal docks of the Canadian Northern Coal and Ore Dock company. The coal is supplied to the iron company on contract by the Pittsburg Coal Company, Limited, of Port Arthur, who control the dock company, the iron company taking the coal as required from the dock pockets, in 6-ton hopper bottom electric lorries, and charging it direct to the coke ovens. In this way the iron company avoids the trouble and expense of storing a large amount of coal.

The coke ovens are erected between the furnace and the coal docks, and are constructed on piling, capped with reinforced concrete, this method of construction being necessary from the nature of the ground on which the battery is built. The one hundred ovens are of the ordinary beehive type, built back to back in a double row. Each oven is charged with 4.5 tons of coal yielding about 2.8 tons of coke, a yield of 62.2 per cent. The coke is drawn by hand labor and loaded into hopper bottom cars which are transferred over the coke pockets at the furnace. Forty-eight hour coke only is made, the physical qualities being but fair, as it is soft and of dark color. The chemical analysis, however, given in the following table, leaves nothing to be desired. The compositoin of the coal, coke and limestone are also shown.

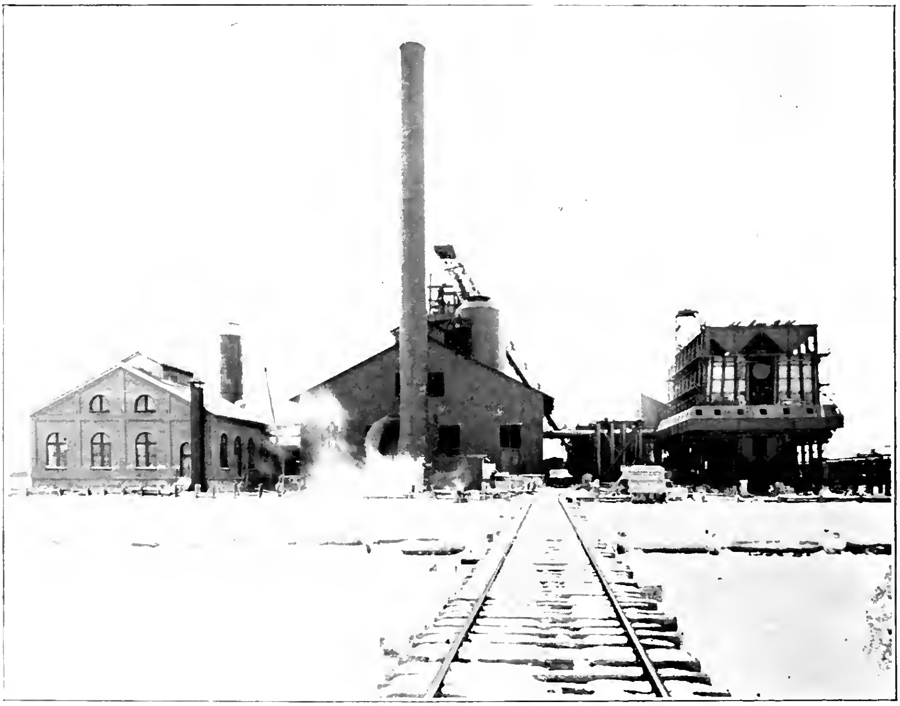
Material.	Fe	SiO_2	Al_2O_3	P.	Mn	CaO	Mg O	S	Fixed Carb.	Vol. Matt.	Ash
Raw Ore	62.14	7.64	0.75	0.12	0.09	2.54	2.18	1.-4.	....	....	....
Roasted Ore	60.06	9.33	0.98	0.162	0.12	2.93	2.3	0.2-0.75	....	....	....
Coal A	....	....	....	0.029	....	....	....	0.66	71 24	22.12	6.64
" B	....	....	....	0.005	....	....	....	0.54	73.84	18.56	7.60
Coke	....	2.90	2.45	....	....	0.34	0.10	0.66	88.08	3.89	8.07
Limestone	....	1.53	0.19	0.003	....	45.34	7.22	0.03	....	....	....

The Blast Furnace

The blast furnace was designed with the view of increasing its capacity at any time to 200 tons per 24 hours with small additional cost. At present the stack is lined down to a capacity of 100 tons daily, the furnace being 75 feet high with diameters at the bosh and hearth of 14 and 8.5 feet respectively, the diameter at the throat being 9 feet. This lining may be enlarged for the second blast to 17 feet diameter at the bosh, with 11 feet hearth diameter, the present construction permitting of this alteration being

made without disturbing the shell or its supporting columns. The furnace bosh is equipped with bronze cooling plates of the Scott type, one row being placed below the tuyeres. The hearth is protected by a 1-inch steel jacket cooled by outside water sprays and is pierced for 9 tuyeres. Two slag notches are provided, one on each side of the furnace; one notch delivering the cinder over a short fall to an ordinary trough water granulator, while the other may be used for flushing off into ladles. By having the two notches the danger resulting from losing either of them is obviated.

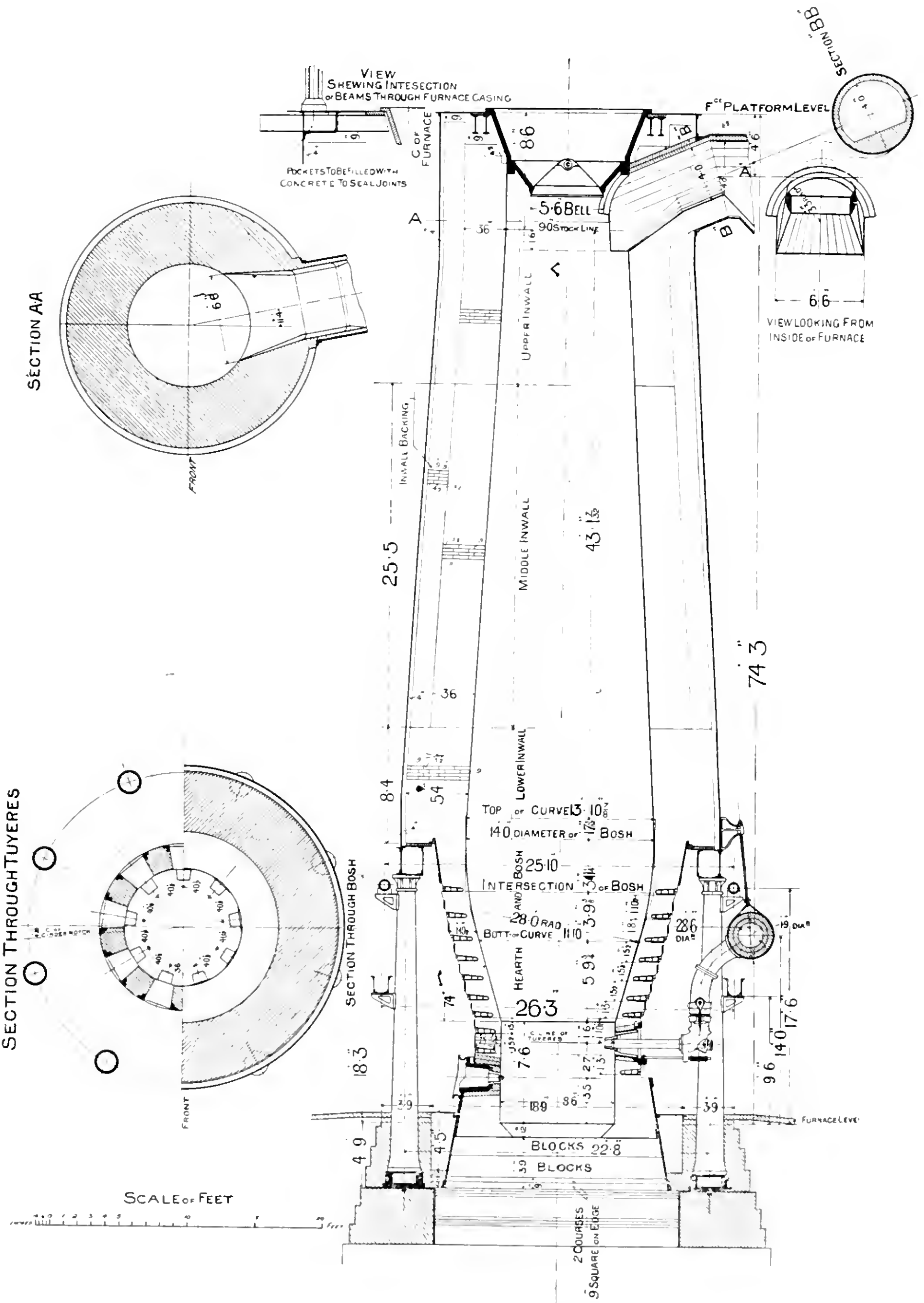
The furnace charging apparatus consists of a double skip steam hoist and sealed top of the Roberts revolving type, the top gear constructed and operated in exactly the same manner as that described for B Furnace of The Hamilton Steel and Iron Company, Limited. The skip cars, each of 125 cubic feet capacity, are filled by means of an electrically operated scale car transferring the ore from the roaster and the lime-



Atikokan Iron Company, Port Arthur. View during construction of blast furnace and roaster.

stone from overhead steel bins. The bin system consists of one large split coke pocket provided with bottom chutes that deliver to either skip car, breeze being got rid of by suitable screens, and 5 smaller pockets for limestone and ore. As the ore bins are located at the bottom of the roaster, only two of the stock house pockets are utilized to provide against possible interruptions in the operation of the roaster. As distributed, the storage capacity of the stock house pockets is as follows: coke 250 tons, ore 500 tons, limestone 175 tons.

The furnace top is provided with a single 18-inch bleeder, and one circular explosion door four feet in diameter. The downcomer is connected to the shell at one point and at its lower end enters a centrifugal dust catcher of the Roberts type, the gas mains from this collector leading to the stoves and boilers. The hot blast stoves are situated in line behind the furnace, and comprise three Roberts-Cowper two-pass stoves 70 feet



Atikokan Iron Company. Lines of the blast furnace.

high and 18 feet in diameter, each having 18,500 square feet of heating surface. All valves are of the latest design, the hot blast and chimney valves being water cooled. These stoves are capable of heating the blast to 1,600 degrees F., but under ordiary conditions not over 1,200 degrees is maintained. The pyrometers for indicating temperatures are placed in the superintendent's office, and were supplied by the Cambridge Scientific Instrument Company, Limited; they are of the electric recording type.

The boilers are installed beside the stoves, both being contained in a steel and corrugated iron building behind the furnace. The battery consists of four Atlas water tube boilers of 225-h.p. each, manufactured by The Canada Foundry Company, Limited, of Toronto. The setting is of special Dutch oven design for the purpose of burning the furnace waste gases with efficiency, and has given very satisfactory results. Steam is supplied to the engine house at 125 pounds pressure. The chimney gases from the boilers and the hot blast stoves are taken by a steel draft stack 150 feet high and 8 feet in diameter, erected on a solid concrete foundation behind the boiler room.

The engine house built alongside the boiler room is of brick and steel construction and contains a disconnected cross compound condensing horizontal engine, manufactured by the Southwark Foundry and Machine Company of Philadelphia, high pressure cylinder 32 inches, low pressure 56 inches with 66-inch blowing cylinders and 48-inch stroke. The air valves are of the gridiron type operated positively, the air suction being through a conduit under the base of the blowing cylinders leading to the outside of the engine house, thereby providing a much drier air than if taken from inside the building. The engine is designed so that either the high or low pressure side may be operated independently. A jet condenser is arranged to operate with the waste water from the furnace and stoves, or with lake water. The pumps for furnace and stove circulation consists of two compound duplex steam pumps 14 x 32 x 14 inches with 20-inch water cylinders, suction direct from the lake; the boiler feed pumps are two, 9 x 5 x 10-inch of the ordinary plunger type. The pumping and condensing plant was supplied by The Canada Foundry Company, Limited. The electrical equipment consists of two 75 kilowatt generators directly connected with a pair of Robb-Armstrong engines, the system having ample capacity for all light and power requirements.

The cast house in front of the furnace is a steel and corrugated iron structure, 160 feet long and 55 feet wide provided with large sliding doors on both sides. The iron is cast in sand beds about 10 feet above the level of the yard, and after being cooled and broken is carried by hand labor to the side doors of the house and chuted to railroad cars alongside, to be either shipped direct or stored as required.

While in blast the furnace was blown with a volume of about 12,000 cubic feet of air per minute, through 4-inch tuyeres at a pressure of 5 to 7 pounds, the temperature of the blast being kept in the neighborhood of 1,200 degrees F.

The average output per diem was 110 tons, the highest tonnage made in any one day being 132 gross tons. The fuel consumption during the campaign averaged 2,600 lb., per gross ton of iron produced.

In the foregoing analyses it will have been noted that the ore, coke and limestone contain only small quantities of slag-forming ingredients and in order to secure a sufficient volume of slag for the removal of sulphur it was found necessary to use a certain proportion of gravel in the charge. This gravel is obtained from Nipigon Bay near Port Arthur and is of the following analysis.

Fe_2O_3	Al_2O_3	SiO_2	P	CaO	MgO	K_2O	Na_2O	H_2O
9.21	13.57	67 0	0.081	0	0.8	1.36	0 9	2.27

The normal furnace charge is made up as follows.—

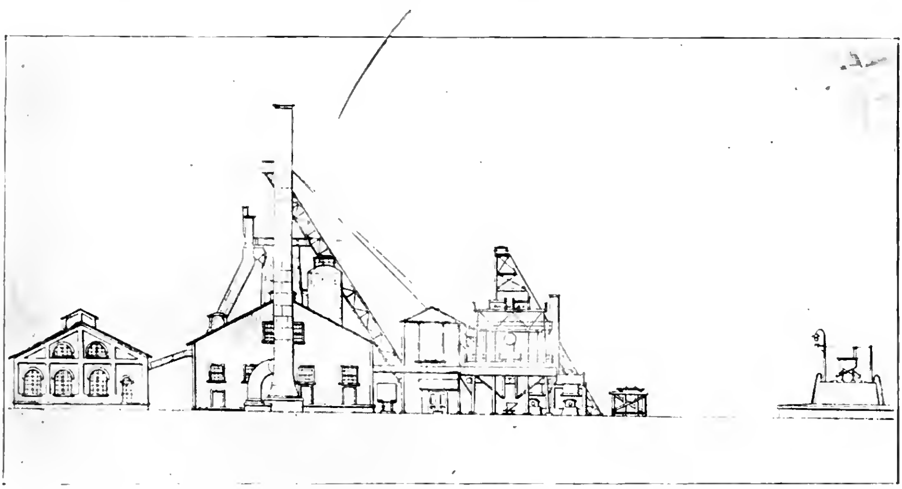
Coke	2,500 pounds.
Ore	3,200 "
Limestone	800 "
Gravel	100 "

It is apparent that the ratio of ore to coke is very low. This is necessitated by the fact that in order to keep the sulphur content of the iron within reasonable limits, the furnace is run with a very hot basic cinder.

Analyses of several Atikokan slags are supplied below:

SiO_2	Al_2O_3	S
27.52	11.36	2.07
33.40	10.60	1.91
34.30	14.00	2.15
29 37	12.78	2.50

The plant was built under the design and inspection of Frank C. Roberts and Company, Philadelphia, Pa., the construction being carried on under the supervision of the superintendent, Mr. Robert R. Jones, to whom thanks are due for all of the above information and the many courtesies received during my visit.



Atikokan Iron Company. Elevation east end of plant, showing power house, boiler house, skip hoists, roaster and bee hive coke ovens.

The Ontario Iron and Steel Company, Limited

This company has recently completed works in Welland, adjacent to the Michigan Central Railway yards, where they have installed one open-hearth basic furnace and complete foundations for a second, an open-hearth steel foundry, and a rolling mill equipped for the production of small rails, bars, angles and pipe skelp.

At present only the steel foundry is in active operation, although the rolling mill and open-hearth departments will, it is expected, be in commision within a short time.

During the last few years the steel casting industry has made rapid progress, turning out numerous machine parts and other pieces formerly made of wrought iron. The demand for this class of castings is now quite large, and the industry has a promising future in Ontario.

The foundry installation is contained in a steel and corrugated iron building 165x150 feet, divided into three bays, the central portion forming the moulding department, the second occupied by a 20-ton open-hearth furnace, and the third containing the chipping and sand storage section. The departments are equipped with three Niles cranes of 30, 5, and 5-ton capacity respectively, for the large and each of the smaller bays, besides several pneumatic jib cranes placed on either side of the casting floor. Two mould drying ovens each 21x60 feet, and one core oven 9x15 feet, are also situated in this building. The chipping department is provided with pneumatic hammers and chippers, air being supplied at 100 pounds pressure by a Canadian Rand compressor belt driven

from a 180-h.p. Canadian Westinghouse induction motor. There is also provided a shaper for machining heavy castings and a Norton grinder for general work. The open-hearth furnace of 20 tons capacity is of the ordinary stationary type, charged by hand labor. The fuel used is natural gas and oil, gas being piped to the plant from the company's own wells near Port Colborne, but as the supply is rather uncertain an auxiliary apparatus is installed at both furnaces for burning oil. The oil is stored in tanks outside the building, and is pumped to the burners where it is atomized and blown into the furnace by an air jet.

The open hearth department, contained in a steel and corrugated iron building 175 feet long and 75 feet wide, is at present equipped with one 25-ton hand charged basic furnace of the stationary type. Foundations for a second furnace are in place, and it is expected that this additional unit will be constructed at an early date. The building is provided with a 40-ton Niles travelling crane for handling the ladles and ingot moulds. Casting is accomplished by the bottom plate or group system, similar to the method employed by The Hamilton Steel and Iron Company, the small sized ingots being necessary as the rolling mill equipment does not include cogging or blooming rolls.

After being stripped, the ingots are placed on small flat cars and conveyed to the rolling mill, which is contained in another steel and corrugated iron building 300 feet long and 100 feet wide, equipped with a 10-ton Niles travelling crane. A continuous heating furnace placed at the entrance to this building, takes the ingots as they are received from the open hearth department, and after being raised to a sufficient temperature they are discharged on the tables of the 22-inch two-high roughing rolls, thence to the hot shears. The slabs are then passed through a re-heating furnace and conveyed to a 12-inch two-high finishing mill delivering to the cooling beds and shipping department. The 22-inch mill is driven by a rope drive from an 800-h.p. Westinghouse 3-phase induction motor. The 12-inch mill is driven in the same way by a 500-h.p. Westinghouse 3-phase motor, both motors running on a 2,200 volt circuit.

Power is supplied from one of the electric generating companies at Niagara Falls, the 3-phase current delivered at 12,000 volts being reduced to 2,200 for the rolling mill by three Canadian Westinghouse step down transformers, and stepped down from 2,200 to 200 volts for the foundry and machine shop by three Packard transformers.

Thanks are due to Mr. D. H. Blaney, superintendent and works manager, who conducted the writer through the several departments at the time of his visit.

Manufacturing Pig Iron in Eastern Ontario[35]

The question of smelting the magnetic ores found in the eastern part of Ontario has been in the past of general interest to all furnacemen operating blast furnaces in the Province. As has been pointed out, much of the ore is unfortunately not of first-class quality, being high in sulphur and in some cases rather silicious, so that, in addition to its low initial value, heavy freight charges in transportation from mine to furnace have added to the difficulty of its being smelted with profit.

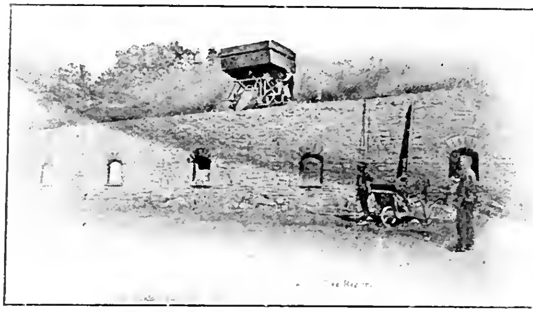
Various projects have been put forward from time to time for the location of a blast furnace at some lake Ontario port that affords railway facilities for transporting the ore from the back townships, and although two such localities, viz: Kingston, the terminal point of the Kingston and Pembroke railway, and Trenton, the terminus of the Central Ontario railway, have been available for a number of years, the furnace plants have not been built. The advantages of placing the blast furnaces at a convenient lake port are twofold. First, the freight rates on ore are minimized, the greatest length of rail haul not exceeding 90 miles as against a haul of 200 to 400 miles to more western furnaces; and secondly, a central market location with ample transportation means by rail or water for shipment of the ore produced. Notwithstanding the attractive

[35] The writer wishes to make thankful acknowledgment to Messrs. Frank C. Roberts and Company of Philadelphia, who kindly prepared all calculations.

TABLE OF THE IRON AND STEEL WORKS IN ONTARIO.

Name of Company.	Blast Furnaces.									Converters, Open Hearth and Puddling Furnaces.			Finishing Departments.		
	No.	Height.	Bosh.	Hearth.	Fuel used.	Ore mixture. Native p.c.	Ore mixture. Foreign p.c.	Product.	Disposition of product.	Bessemer Converters.	Basic open hearth Furnaces.	Puddling Furnaces.	Rolling Mills.	Steel Foundry.	Finished Product.
The Algoma Steel Co., Ltd	1	70 ft.	17 ft.	11 ft.	coke	25	75	Bessemer	Used	Two 4-ton acid convertors.	Two 40-ton furnaces	....	1 rail mill	....	Steel rails
do do do	2	80 ft.	17 ft.	11 ft.	coke	25	75	Basic Bessemer	Used						
The Hamilton Steel & Iron Co., Ltd.	A	75 ft. 6 in.	16 ft.	10 ft.	coke	40	60	Basic Foundry Malleable	Part used and part sold.	....	Two 40 ton Two 20 ton	4 double furnaces	Two	One small	Merchant bars, small rails, plates, forgings.
do do do	B	80 ft.	20 ft.	13 ft.	coke	25	75	Basic Foundry Malleable	Part used and part sold						
The Canada Iron Furnace Co., Ltd.	1	64 ft. 6 in.	13 ft.	8 ft. 6 in.	coke	45	55	Bessemer Foundry Malleable	Sold	....	....	....	....	....	....
The Deseronto Iron Co., Ltd.	1	61 ft.	10 ft. 6 in.	6 ft. 5 in.	coke	15	85	Foundry Malleable	Sold	....	....	....	....	....	....
The Atikokan Iron Co., Ltd.	1	75 ft	14 ft.	8 ft. 6 in.	coke	100	....	Foundry	Sold	....	....	....	....	....	....
The Ontario Iron and Steel Co., Ltd.	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	One 25-ton One 20-ton	....	One	One large	Merchant bars, small rails, skelp, steel castings
The Electro Metals Co., Ltd.	Four Heroult furnaces 1000–1500 h. p. capacity, manufacturing ferro-silicon, ferro chrome, etc. One furnace, 400 h. p. capacity, manufacturing pig iron.														

sites presented by easy communication with the iron mines and a growing market in a populous manufacturing portion of the Province, there has been a noticeable hesitancy on the part of ironmasters to embark in the business of iron smelting in Eastern Ontario.



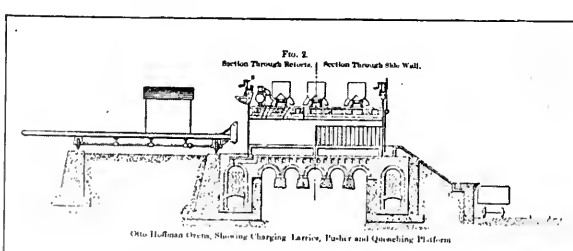
A battery of beehive coke ovens (by-products lost).

Conditions for the Industry

Doubts have been expressed of the probability of the district under consideration being able to supply a blast furnace of modern dimensions for any great length of time. It is true that the amount of merchantable ore mined is small, but if the furnace plant were supplemented with a magnetic concentrating mill and probably an ore roaster, numerous low grade deposits would become available, and the supply drawn from many sources would in the opinion of the writer be amply sufficient to meet all possible requirements.

Limestones of good quality for blast furnace use are found in many localities throughout the district, and in deposits of size that guarantee an ample supply being delivered to the furnaces for not more than $1.00 per net ton. The Provincial Geologist, Dr. W. G. Miller, is the author of a report published by the Ontario Bureau of Mines, entitled "The Limestones of Ontario," which contains full and accurate information concerning the deposits of limestones in the eastern part of the province.

The question of fuel is of paramount importance, as it controls in a marked degree the final costs of the pig iron manufactured. It is idle to speculate on the use of charcoal, because cordwood for its making can not be obtained in quantity nor at reasonable prices, therefore the only alternative is coke fuel. The problem may be



The Otto Hoffman by-product coke oven (by-products saved).

solved in two ways: either by importing coke direct from the Pennsylvania fields in the United States, or by importing coal and manufacturing coke in by-product coke ovens. If coke is imported, it may be brought in via Niagara Falls and will cost approximately $5.50 per net ton f.o.b. furnace. If it was decided to manufacture coke, the necessary

coal could be shipped to Charlotte, New York State, transferred to boats and unloaded at the oven docks on the Ontario side for about $2.75 per net ton, and the cost of coke manufactured therefrom would approximate $3.86 per net ton delivered to the furnace. The installation of a by-product coke oven plant which would have to be equipped with labor-saving coal and coke handling machinery, would require a good deal of capital, but as the use of this coke manufactured alongside the furnace plant means a saving of $1.64 per net ton over the use of imported coke the return on the capital invested would be considerable. It is assumed that by-product coke ovens would be more desirable than the ordinary beehive type, as the saving of the distillation products is not only in keeping with the modern practice, but is absolutely essential for the economic production of coke from high priced coal.

The cost of the ore mixture at the furnace will depend directly upon the mining and concentrating costs of the low grade ores. If a roaster is erected in conjunction with the furnace, a considerable amount of high sulphur magnetite could be treated therein without resort to the concentrating process. This complicates matters slightly, and it might be found more profitable to concentrate all ores with subsequent nodulizing or briquetting. However, it will be assumed that from 50 to 60 per cent. of the ore mixture will consist of nodulized or briquetted concentrated ores, which will cost say $4.00 per net ton at the furnace, and that the balance of high sulphur ores when roasted will cost approximately $2.60 per net ton at the furnace. It is also assumed that the blast furnace will be of 250 gross tons capacity per 24 hours and equipped with all modern labor saving appliances.

The following costs of production and estimated profits were prepared by the well-known firm of Frank C. Roberts and Company, of Philadelphia, Pa., and Middlesbrough, England, blast furnace designing and constructing engineers. This engineering company has of late completed the erection of two modern blast furnaces in Ontario, namely, No. 1 stack of The Atikokan Iron Company at Port Arthur, and B furnace of The Hamilton Steel and Iron Company. Descriptions of these furnace plants will be found elsewhere in this report, and it may be stated that both The Atikokan Iron Company and The Hamilton Steel and Iron Company are well pleased with the construction and operating efficiency of their furnaces. The figures quoted in this estimate, should (it is hoped), demonstrate that the smelting of eastern Ontario magnetites can be made a profitable undertaking if carried out along the lines suggested. The estimate may be considered a conservative one, as it comes from an enginering firm, possessing valuable experience in the manufacture of iron, and there can be no doubt that it fairly represents the expected profits accruing from such an industry.

The following explanatory letter from Mr Frank C. Roberts should be studied in conjunction with the estimate:—

Philadelphia, April 1, 1908.

Dear Sir,—We are sending you to-day the following:—

1st. Estimates of cost of production of pig iron and coke.

2nd. Blue print of drawing No. 3603—General arrangement of blast furnace and coke plant.

3rd. Blue print of drawing No. 3188—General plan, Atikokan Iron Company.

In connection with the foregoing, please note the following:—

By-Product Coke. The estimates of cost of producing coke, etc., are based upon by-product ovens with the complete chemical plant required for the recovery of the various by-products mentioned in the statement of cost of production. We have assumed a cost of coal of $2.75 net per ton; should you decide to use any other price, it would be a simple matter to make the correction in the estimate.

It should be borne in mind that the cost of by-product coke will be largely influenced by the price to be obtained for the surplus gas. We have assumed 15 cents per thousand cubic feet, but if it is possible that the gas can be sold for illuminating purposes, the price may be in excess of this amount.

Pig Iron. The estimate of cost of $700,000 is not that which would ordinarily apply to a furnace plant. In most cases an estimate of the cost of a furnace plant includes the furnace with its equipment, but does not embrace such items as spare parts, office

building, laboratory, yard tracks, etc., etc. We have thought it best in this case, however, (since it is an entirely new operation) to include everything necessary for the operation of the plant; as a consequence, the estimate of cost is considerably higher than it would otherwise be. It frequently happens that a furnace plant is built as an addition to a plant already in existence, so that many of the items included in the estimate under consideration, do not need to be taken account of.

It is also to be noted that the estimate includes a roaster having a capacity of about 400 tons, whereas only 200 tons of roasted ore are needed. If it is thought wise to instal roaster capacity for 200 tons only, the estimate would be reduced about $20,000.

Iron Ore. It is assumed that of the 450 tons of ore required per day, 200 tons will be obtained from the Coe Hill, Robertsville, Calabogie and Glendower mines, and that this ore will require roasting. If ten cents per ton be allowed for roasting, this ore will cost at the furnace $2.60 per ton based upon the prices you gave us.

The remaining 250 tons have been assumed to be nodulized concentrates at $4.00 per ton. The cost of this mixture would approach $3.37 per ton. It is quite probable that the mixture finally used would not be that given above, but for the present purposes we think that the price of $3.50 per ton is sufficiently near the average price to warrant its use.

General. It is to be noted in connection with the estimates of cost that they are based upon the assumption that there will be no extraordinary expense incurred in foundations or in water supply.

Estimated Profits. You will notice that we have not inserted the bounty on pig iron and as a consequence the profits are not completely shown or the return on the investment. We are not familiar enough with the situation to insert this item, and therefore leave it for you to do; kindly advise us of what addition you will make in order that our records may be clear.[36]

If any statistics are available giving the price of foundry iron in Eastern Ontario, for any term of years, you might find that the price of $16.75 given in our statement is too low and that profits to be expected from a blast furnace would be greater than those shown.

In connection with the coke we have shown the profit over the selling price named by you for coke at the proposed site.

Blue Prints. Drawing No. 3,603 shows an arrangement of two furnaces with coke plant capacity for both; the furnace to be first built, together with coke plant, roaster, etc., are shown in heavy lines, whereas the second furnace, coke plant, etc., are shown in dotted lines. We have indicated the plant as located alongside of a dock, but have not included in our estimates, either the value of the land or the cost of the dock.

Drawing No. 3188 shows the general plan of the plant of The Atikokan Iron Company, and we are sending it to you, thinking that it may interest you in connection with this matter.

In accordance with your instructions our figures are based upon the plant being built at ———, Ontario.

Should there be any further information that you desire, kindly let us know.

Yours truly,

(Signed) Frank C. Roberts & Co.

P.S.—We wish to particularly call your attention to the fact that costs of production carry a depreciation charge of 5 per cent. of the cost of the plants—both coke and furnace.

F. C. R.

Cost of Manufacturing By-Product Coke

Capacity	300 net tons per 24 hours.
Yield in furnace coke	73 per cent.
Daily coal requirements	411 net tons per 24 hours.
Cost of coal alongside of dock	$2.75 per net ton.
Estimated cost of coke plant	$775,000.00
Operating cost of plant; per net ton coal—	
Coal unloading	.080
Labor, office expenses, etc.	.311
Supplies	.080
Electric Current	.031
Water	.008
Repairs	.120
Total	.630

[36] The writer has inserted the bounty rate of 90 cents for the year 1910, and has added calculation of profits without considering the bounty, using Connellsville and by-product coke. The bounty Act of 1907 will terminate with the end of the calendar year 1910.

Cost of Manufacturing By-Product Coke.—Continued.

Daily Expenditures:		
411 net tons of coal at $2.75	$1130.25	
Operating cost at 0.63 per ton	258.93	
Depreciation, 5 per cent	110.00	
		$1499.18
Daily Receipts:		
6 gals., tar per net ton coal—		
2466 gals. at 0.018	44.39	
$3\frac{1}{4}$ lbs. NH_3 per net ton coal—		
1336 lbs. at 0.08	106.88	
411 gals. benzole at 0.15	61.65	
2250 cu. ft. surplus gas per net ton coal—		
924,750 cu. ft. at 0.15	138.71	351.63
Daily cost 300 net tons furnace coke at ovens		$1147.55
Cost per net ton of coke at ovens	3.82	
Delivery to furnace	.04	
Cost of coke per net ton delivered at furnace	3.86	

Cost of Manufacturing Foundry Pig Iron

Capacity required		250 gross tons per 24 hours.
Number of furnaces		One.
Cost of ore per ton delivered at furnace		$3.50 per gross ton.
Ore per ton of Iron		1.8 per gross ton iron.
Cost of ore per gross ton of iron		$6.30
Cost of by-product coke at furnace		3.86 per net ton.
Coke per gross ton iron		2400 lb.
Cost of coke per gross ton iron		$4.63.
Cost of limestone at furnace		1.00 per gross ton.
Limestone per gross ton iron		1200 lb.
Cost of limestone per gross ton iron		.54
Estimated cost of furnace plant, including roasters		$700,000.00
Cost of manufacture with by-product coke:		
Ore mixture		$6.30
Limestone		.54
Coke, (by product)		4.63
Incidentals, supplies, etc	.50	
Relining	.25	
Labor	.80	
Salaries, office expenses, etc	.25	
Depreciation, 5 per cent	.40	
		2.20
Cost of pig iron per gross ton		$13.67
Cost of manufacture with Connellsville coke:		
Ore mixture		6.30
Limestone		.54
Coke, 2400 lbs. at $5.50 per net ton		6.60
Labor, supplies, etc., as above		2.20
Cost of pig iron per gross ton		$15.64

Cost of Plant:—		
Furnace plant proper	$625,000.00	
Roaster, 400 tons capacity	75,000.00	$700,000.00
By-product coke plant, capacity 300 tons daily		775,000.00
Total cost		$1,475,000.00

Estimated Profits

Pig Iron:—There are no available records of the prices at which pig iron has been sold in eastern or central Ontario for a period of years. It would seem conservative to base the estimate of profits on the average price of No. 2 foundry at Chicago for the ten years 1897-1906. The published records of the Iron Trade Review give this average as $16.75 f.o.b. Chicago. If we assume this as the average price, f.o.b. eastern Ontario points the profits will be as follows:—

Using Connellsville coke and including bounty of 1910:	
Average price No. 2 foundry at furnace	$16.75 per gross ton,
Cost with Connellsville coke	15.64 " "
Profits per ton	1.11 " "
Annual tonnage, (345 days)	86,250 gross tons.
Profit, (annual) 86,250 tons at $1.11	$ 95,737.50
Bounty, 86,250 tons at .90 for year 1910	77,625.00
	$173,362.50
Return on Investment of $700,000	24.76 per cent.
Without the bounty, using Connellsville coke:	
Average price of No. 2 foundry at furnace	$16.75 per gross ton.
Cost with Connellsville coke	15.64 " "
Profit per ton	1.11 " "
Annual tonnage (345 days)	86,250 gross tons.
Profit, (annual), 86,250 gross tons at $1.11	$95,737.50
Return on investment of $700,000	13.67 per cent.

Coke:—Assuming that the selling price of Connellsville coke at the furnace, i.e., $5.50, be charged against the furnace operations and credited to the coke plant, and that the cost of production is as per statement, the yearly profits from the coke plant would be as follows:—

Selling price at the furnace per net ton	$5.50	
Cost of production	3.86	
Profit per ton	1.64	
Annual tonnage, (345 days)	103,500 tons.	
Profit, (annual), 103,500 tons at $1.64	$166,014	
Return on investment of $775,000	21.5 per cent.	
Profits from combined coke and furnace plant, (with the bounty):		
Yearly profit from pig iron	$95,737.50	
Bounty	77,625.00	
		$173,362.50
Yearly profits from coke plant		166,014.00
Total yearly profits		$339,376.50
Return on Investment of $1,475,000.00	23 per cent.	
Profits from combined coke and furnace plant, (without the bounty):		
Yearly profits from pig iron	$ 95,737.50	
Yearly profit from coke plant	166,014.00	
Total yearly profits		$261,751.50
Return on investment of $1,475,000	17.74 per cent.	

In the opinion of the writer, the average price for No. 2 foundry iron, given in the estimate at $16.75, is considered too low, and therefore does not truly represent the situation. In connection with this the following letter will be of interest:—

Philadelphia, Pa., April 6th, 1908.

Dear Sir,—Referring to our recent letter, we would be much obliged if you would let us know what you find the average price of No. 2 Foundry Pig Iron to have been at —— for the last ten years. Please state whether this is per net or per gross ton. In addition, if you can do so, kindly give us the average price per net ton of Connellsville coke at —— for the last ten days.

In showing the profits in the operation of the furnace, the average prices both for coke and pig iron should be used. We think that the statement made by us is hardly fair to the situation, since it gives a low price for iron and a high price for coke. In other words, a statement of the profits to be expected from the furnace, based upon average prices for both coke and pig iron, would show the furnace to be a better investment than our figures indicate.

Yours very truly,

FRANK C. ROBERTS & CO.

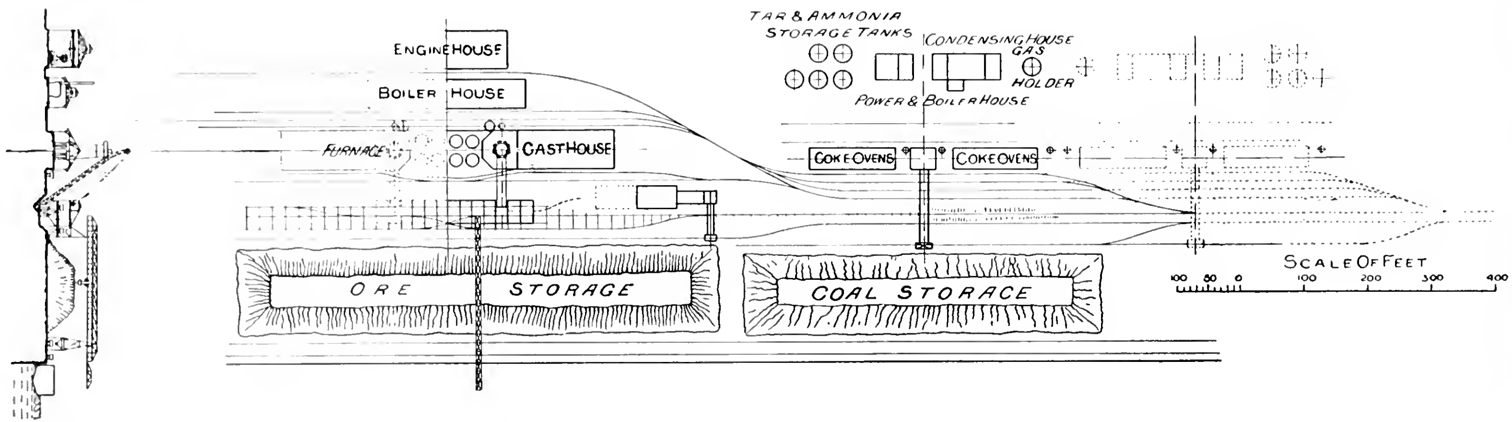
An effort was made to obtain reliable data on this point from a well-known firm of iron and steel merchants doing business in Ontario, but the request was not granted. However, definite information was secured from consumers who stated that during the past ten years they had paid a maximum of $25.00 and a minimum of $17.00 per gross ton of foundry iron delivered at their works; the average price per gross ton of No. 2 foundry being in the neighborhood of $19.00. It should be pointed out that these figures are not official trade price averages, as they are representative of one or two cases only. During the present depressed condition of the iron market, the price for No. 2 foundry in eastern Ontario will approximate $17.00 per gross ton.

The figure of $5.50 per net ton for Connellsville coke delivered, is taken at a maximum, but it is quite possible that this price could be reduced if large quantities were contracted for.

Pig Iron and Steel by the Electric Furnace

Of late years a great deal of attention has been paid to the manufacture of certain ferro alloys, pig iron and steel by the electric process. No attempt will be made here to give detailed descriptions of the various electric processes, but rather a short summary of what has been accomplished in this direction, within the Province of Ontario, during the past few years.

Until 1904 very little had been heard in Canada about the electric furnace and its application to the manufacture of iron and steel, and it remained for Dr. Haanel,



General arrangement blast furnace and coke plant.

of the Mines Department, Ottawa, to bring this new phase of metallurgy before the public in a most interesting publication, entitled "Report of the Commission Appointed to Investigate the Different Electro-Thermic Processes for the Smelting of Iron Ores and the Making of Steel, in Operation in Europe." This report not only furnished full descriptions of the various electric furnace plants operating in Europe, but also supplied complete data covering the costs of production, together with mechanical and microscopic tests of the steels produced by several different processes.

During the winter of 1905-1906, a small experimental furnace was erected and operated at the plant of the Lake Superior Power Company at Sault Ste. Marie. This test, extending for about a month and a half, was conducted under the supervision of Dr. Haanel, who was assisted by Dr. Heroult in the design and subsequent operation of the furnace. The result of the experiment was the production of about 55 tons of pig iron from various ore mixtures, some of which were high in sulphur. Not only was foundry iron of good quality made, but the production of pig iron containing nickel and titanium was accomplished with very little trouble. Full data covering the results obtained from the series of tests conducted at Sault Ste. Marie have been published by the Mines Department, Ottawa, and can be obtained by any one interested enough to make application for a copy.[37] The experimental plant used by Dr. Haanel was subsequently purchased by The Lake Superior Corporation, who operated it for some time, producing in the neighborhood of 150 tons of nickel pig.

During the experiments at Sault Ste. Marie, Dr. Haanel had associated with him Mr. R. Turnbull, an expert in the design and operation of electric furnaces. In July 1906 Mr. Turnbull undertook the erection and operation of an electric furnace in Shasta county, California, for Mr. H. H. Noble, a resident of San Francisco. The results of this trial have been given in "The Mining World" of Chicago,[38] and also by Mr. Turnbull himself in Vol. XI of the Journal of the Canadian Mining Institute.[39] After returning from California, Mr. Turnbull, with Mr. R. H. Wolff, of New York City, organized the Electro Metals Company, Limited, with headquarters at Welland, Ont., for the production of pig iron by the electric process. The site was particularly well chosen, for not only were transportation facilities first class, but also the proximity to Niagara Falls assured the securing of electric power at reasonable cost.

The original idea of manufacturing pig iron at Welland was not carried out at first because of expected improvements that were being made in a new type of furnace designed by Dr. Heroult, and until Dr. Heroult's furnace had been tested, the Welland plant was operated for the production of ferro-silicon, with the expectation of manufacturing ferro-chrome and ferro-tungsten at a later date. This spring construction on a 400-h.p. furnace for the smelting of iron ores was started, and if the experiment is successful, it will be followed by the installation of a much larger furnace.

In view of the interest evinced in the production of iron and steel electrically, it may be worth while to indicate in what manner successful results may be expected, and explain some of the advantages and disadvantages of the process. The following extracts are taken from a paper read by Dr. Stansfield of McGill University before The Canadian Mining Institute in March, 1908, and the writer wishes to make grateful acknowledgment of Dr. Stansfield's permission for the unrestricted use of his valuable monograph.[40]

The Electric Process of Steelmaking

In the ordinary metallurgy of iron the ore is smelted in a blast-furnace with coke, producing pig-iron. This is an alloy of iron with some 2 to $4\frac{1}{2}$ per cent. of carbon, $\frac{1}{2}$ to 4 per cent. of silicon and small quantities of other elements. It is decidedly more

[37] Preliminary Report, on the Experiments made at Sault Ste. Marie, Ont., under Government auspices, in the smelting of Canadian iron ores by the Electro-thermic Process, by Eugene Haanel, Ph. D., Dept. of Mines, Ottawa

[38] The Mining World, Volume 27, page 197.

[39] The Reduction of Iron Ores in the Electric Furnace. by R. Turnbull, St. Catharines. Journal of The Canadian Mining Institute. Vol. XI.

[40] Possibilities in the Electric Smelting of Iron Ores, by Alfred Stansfield, D. Sc., Montreal; Journal of the Canadian Mining Institute, Vol. XI.

fusible than wrought iron or steel, and on this account is very suitable for foundry purposes. Bessemer steel and open-hearth steel are made from pig-iron by removing from it in the Bessemer converter, or the open-hearth furnace, a considerable proportion of the carbon, silicon, etc., which it contains, the product being nearly pure iron, retaining a little carbon and some manganese.

Crucible steel is used for tools. It contains about 1 per cent. of carbon, and is made by adding the necessary amount of this element to pure varieties of iron or steel, and melting the material in crucibles so as to obtain a perfectly sound product.

Electrical energy has recently been employed to replace, in such operations, the heat which is ordinarily obtained by burning fuel. Electrical energy is somewhat expensive, and it was naturally employed at first for the production of the more valuable products, such as crucible steel, where the cost is of less importance. The electrical production of cast steel for tools and similar purposes may be accomplished in two ways:—(1) By melting down pure varieties of iron and steel with suitable additions of carbon and other ingredients, just as in the crucible process, but using electrical energy for heating instead of coke or gas; (2) By melting a mixture of pig-iron and scrap steel as in the open-hearth process, and removing the impurities, such as sulphur and phosphorus so thoroughly, by repeated washing with basic slags, that a pure molten iron is at last obtained. This can then be recarburized and poured into moulds. Both of these methods are now employed commercially for the production of good qualities of tool steel. The larger sizes of electrical furnace that have already been constructed hold five or ten tons, while the crucible will only hold about 80 lb., and the high efficiency of the electrical method of heating more than compensates for the greater initial cost of electrical energy as compared with heat derived from fuel. The resulting steel is found to be even better than crucible steel, and can be produced at less cost. It is, therefore, only a question of time until the crucible process shall be entirely replaced by the electrical process in all localities where electrical energy can be produced at a moderate figure.

Two forms of electrical furnace have been used for making cast steel:—(1) The Heroult steel furnace, which resembles an open-hearth furnace, through the roof of which hang two large carbon electrodes. Electrical connection is made to these carbon electrodes, and electric arcs are maintained between the lower end of each electrode and the molten slag in the furnace, thus producing the necessary heat. This form of furnace has been found to be very suitable for the second of the above processes, that is, the one in which pig-iron and scrap steel are melted together and refined until pure enough to convert into cast steel.

An entirely different form of furnace has been devised in which no electrodes are required. This furnace consists of an annular shaped trough containing the steel. This ring of steel acts as the secondary of an electrical transformer. An alternating current is supplied to a primary winding, and the primary winding and the ring of steel both encircle an iron core, as in the ordinary transformer. The alternating current in the primary circuit induces a very large alternating current in the secondary circuit, that is, in the ring of steel, and in this way enough heat is produced to melt the steel. This type of furnace has been constructed lately in somewhat large sizes holding as much as eight tons of steel and consuming 1,000 electrical h.p. It is apparently well suited for the first mentioned process, that of melting down pure varieties of iron and steel just as in the crucible process.

The amount of energy needed in these furnaces amounts to about 800 or 900 K.W. hours per ton of steel, using cold stock, or 600 or 700 K.W. hours when the pig-iron, which usually forms part of the charge, is supplied molten. This amount of electrical energy would cost more than the coal used in producing the same amount of steel in the open-hearth furnace, but the resulting steel is far more valuable than the open-hearth steel.

The above short account of the production of crucible steel in the electric furnace has been introduced, as this is the only commercial process for the production of iron or steel which is at present in operation. The present paper deals rather, however, with the electrical smelting of iron ores.

Electric Methods of Making Pig Iron

In reducing iron ore to a metal, iron can be obtained in a relatively pure state, such as wrought iron, and this was the method adopted by the ancient metallurgists in their small furnaces or hearths; but in the modern blast-furnace, with its higher temperature the coke which is needed for the production of heat carburizes the resulting iron, producing pig iron. In the electric furnace, however, fuel is not used for the production of heat, since this is obtained electrically. Some carbonaceous material must be added to the charge in order to eliminate the oxygen of the ore yielding metallic iron, but the amount of this carbonaceous material can be regulated so as to yield either pure iron, steel or pig-iron at will.

Although this has been realized by the pioneers in the electric smelting of iron ores, certain difficulties in the operation have led them to smelt the ore for the production of pig-iron instead of for the production of steel, although the difference in price of these materials would be sufficient to pay for all the electrical energy needed for the direct production of steel from iron ore, and it is surprising that this more attractive proposition has not gained more attention from metallurgists.

A number of experiments have been made on the direct reduction of steel from iron ore in the electric furnace, but the most satisfactory work that has been accomplished relates to the production of pig-iron frm the ore, and this will be described first. This work has been carried out by Heroult, Keller and others. The furnaces they have adopted are similar to the one employed by Heroult recently in the experiments at Sault Ste. Marie. This consisted of a vertical shaft similar to a small blast-furnace, in which hung a central carbon electrode. The crucible of the furnace was lined with carbon and served as the other electrode, the electric current passing between the hanging electrode and the molten metal in the crucible of the furnace. The ore with fluxes and carbon sufficient for its chemical requirements, was fed in around the vertical electrode, and became heated and melted by the heat produced by the passage of the current. The electric current in this furnace produces enough heat to carry out the chemical reactions involved in the reduction of the ore to metal, and the fusion of the resulting pig-iron and slag. The carbon is required for the reduction of iron oxide to metal, and for the carburization of the metal to form pig-iron.

The Keller furnace is practically the same as the Heroult furnace, except that it consists of two shafts instead of one and that these two shafts are worked in conjunction with one another, the current entering through the vertical electrode in one shaft and leaving by the vertical electrode in the other shaft. A connecting trough or passage enables the electric current to flow from one part of the furnace to the other, and serves to collect the resulting pig-iron and slag from both of the shafts. This furnace has the advantage of using a higher voltage than the single shaft furnace of Heroult. The results of operating furnaces of this class show a consumption of electrical energy of about 0.3 h.p. year and about 800 or 900 lb. of coke or good charcoal per long ton of pig-iron. Supposing that the general costs of operating this furnace and the blast-furnace were equal, these figures would indicate that the electrical furnace would need to obtain energy at a cost per h.p. year of less than that of two tons of coke in order to compete with the blast furnace. Thus, if coke costs $3.00 a ton and electrical energy $5.00 per h.p. year the cost would be about the same by the two processes, and with power at $12.00 per h.p. year, the electric furnace could not compete with the blast furnace unless the price of coke were as high as $7.00 per ton. In considering these figures, it should be remembered that the heating power of one electrical h.p. year is about the same as that of three-quarters of a ton of good coal or coke, assuming that the latter is completely burned. Looked at from this point of view, it will be obvious that even these small and admittedly imperfect electric furnaces are more economical, that is to say, they use the heat better than the large blast furnaces.

Advantages of the Electric Furnace

The electrical furnace possesses certain advantages over the blast furnace, which in some cases may over-ride the high cost of electrical power. One is its ability to use without much trouble ores of a sandy or powdery character. This ability depends upon the absence of a blast in the electrical furnace. In the blast-furnace powdery ores are liable to be blown out of the furnace by the blast, or they obstruct the passage of the blast through the furnace. In the electric furnace there is no blast introduced, and these difficulties are less serious. Another advantage of the electric furnace is in regard to the smelting of titaniferous and other difficultly fusible ores. In the blast-furnace these ores are liable to give trouble on account of the slag becoming pasty, but in the electric furnace it is possible to obtain a higher temperature and thus to overcome any difficulty of this kind. The high temperature which can be obtained in the electric furnace is advantageous in regard to the treatment of sulphurous ores. In the iron blast-furnace, the sulphur contained in the coke or the ore is prevented from entering the pig-iron by the presence of lime and by maintaining strongly reducing conditions in the furnace; the lime then forms calcium sulphide, which passes into the slag. In the electric furnace it is posible to obtain higher temperatures, thus enabling a larger proportion of lime to be used, and even more strongly reducing conditions to be obtained than in the blast-furnace. Large amounts of sulphur can, therefore, be eliminated in the electric furnace, as has been shown in the experiments at Sault Ste. Marie.

Another point in favor of the electric furnace is that it does not require, as the blast-furnace does, a very high quality of coke for fuel. In the blast-furnace a soft or powdery coke becomes crushed and obstructs the action of the furnace, and is less

efficient than a harder variety; but in the electric furnace, where the coke or charcoal is needed merely as a chemical re-agent, any convenient form of carbon can be employed —coke, charcoal or small anthracite—and probably in improved furnaces even such fuel as peat, sawdust or soft coal could be utilized for reduction.

Difficulties yet to be Overcome

Looked at from a commercial point of view, the electric furnace producing pig-iron has many difficulties to overcome before it can compete successfully with the blast-furnace. One very important difficulty is the small scale on which the electric furnace has so far been constructed. It will be seen from the account of the Heroult furnace that the height of the shaft of this furnace is limited by the length of the electrode which is introduced into it. More recent furnaces have been designed by Dr. Haanel and by Mr. Turnbull, in which this difficulty has been overcome by a system of inclined or lateral shafts down which the ore passes, so that the electrode does not hang down the whole height of the ore column. Another weak point in the construction of the electric furnace is that no provision has been made for utilizing the carbonaceous gases which escape at the top of the furnace. In the Turnbull furnace already referred to, it is proposed to utilize the gas by burning it in a rotating tube furnace down which the ore passes before it enters the electric furnace and is mixed with the charcoal. In this way the heat available in this gas will be utilized, and an economy in the working of the furnace may be expected

In view of the importance of reducing the consumption of fuel and electrical energy to the lowest possible point, the writer has calculated what could be expected in this way if the gases arising from the reaction between the charcoal and the ore were used partly for the reduction of the ore and partly for pre-heating the ore. Such a result could be attained in a furnace consisting essentially of three parts. In the upper part, the otherwise waste gases are burned by air introduced there, and communicate their heat to the incoming ore to which the fluxes but not the charcoal have been added. In the middle portion of the furnace, the gases arising from the lowest portion, which may be considered to be wholly carbon monoxide, react on the heated ferric oxide, if that were the variety of the ore to be treated, and reduces it to ferrous oxide. The charcoal is introduced in the lowest section of the furnace and completes the reduction of the ore to metal. Electrical energy is introduced into this section of the furnace and serves to melt the resulting pig-iron and slag, and to supply the heat necessary for the preceding chemical reaction. The details of the construction of such a furnace have not been worked out at present. In a furnace of this kind it can be calculated that one ton of pig-iron can be obtained from an average ore by the use of 0.2 h.p. year of electrical energy and about 600 to 800 lb. of coke or good charcoal. This includes a reasonable allowance for loss of heat. A further allowance should be made for irregularity in the use of the electrical power, and taking this into account, we may consider that one quarter of a h.p. year and 600 to 800 lb. of coke or charcoal would be required for one long ton of pig-iron from the ore.

Considering these figures, it will be seen that the use of $\frac{1}{4}$ electrical h.p. year will save about $\frac{2}{3}$ of a ton of coke, or that 1 electrical h.p. year should not cost more than $2\frac{2}{3}$ tons of coke, if the electric furnace is to compete with the blast furnace. Thus an electrical h.p. year at $12.00 would correspond to coke at $4.50 a ton. The considerations previously mentioned in regard to the use of cheaper fuel and cheaper ore in the electric furnace would also apply in this case, and with improved design and construction the size of the electric furnace may be increased so as to admit of a large and economical output of pig-iron.

Cost the Dominant Factor

The direct reduction of steel from the ore has been carried out by Stassano and others, but no economical scheme for this purpose has ever been put into operation on a large scale. The Stassano furnace consists of a chamber, about one metre cube, lined with magnesite bricks. The ore, mixed with the necessary fluxes and charcoal for its reduction and made up into briquettes, is placed in this chamber, and is heated by an electric arc which is maintained above the ore. In this furnace it is possible to reduce the ore to metal and to remove any impurities, such as sulphur and phosphorus, although Stassano did not actually demonstrate this as the ores he employed were very pure. The method of heating the ore is, however, uneconomical, and it was not to be expected that commercial results could be obtained. Stassano still experiments with his furnace but no longer uses it for the direct reduction of the ore.

Steel has also been obtained directly from the ore by Dr. Heroult in his electric steel furnace mentioned in the early part of this paper, but he found the process uneconomical, and preferred to use pig and scrap as the materials for making steel in his furnace. Experiments in the laboratory have been made at different times with

a view to the direct reduction of iron ore to steel. In this connection may be mentioned the experiments of Messrs. Brown and Lathe in the metallurgical laboratory at McGill, which were described in the last number of the Institute Journal.[41] These experiments are being continued this year, and the writer hopes to be able to communicate some interesting results at a later date.

In any operation for the direct reduction of iron ore to steel the following difficulties should be borne in mind:—

1. The difficulty of eliminating sulphur when this is present in the ore, the blast-furnace producing pig iron being far more efficient in this particular than a steel furnace such as the open hearth. It may possibly be necessary on this account only to use ores that are relatively free from sulphur in the direct production of steel.

2. Another difficulty lies in the different conditions required for the reduction of the ore and the final refining treatment to which the resulting steel must be subjected. Thus the operation of making steel must always be intermittent in character, while the reduction of ore in the blast furnace is a continuous operation.

Until these and other difficulties have been overcome, it is not likely that we shall have any successful production of steel directly from iron ore on a commercial scale. Nevertheless, the high price of steel as compared with pig-iron renders this proposition particularly attractive to the electro-metallurgist. At present the most satisfactory method appears to be that of reducing the ore to pig-iron in one furnace, and turning this into steel in a separate furnace as in ordinary metallurgical practice.

The Lash Mixture for Making Steel

A company has been formed to exploit the Lash process of making steel, and a description furnished by the company itself shows the essential feature of the process to be a mixture of finely divided iron ore and carbonaceous materials such as coal tar and coke, together with pulverized or granulated pig iron, sawdust and flux, in which iron ore constitutes about 60 per cent. by weight. The claim is made that when charged in the furnace the mixture needs only to be heated to a sufficiently high temperature in order to produce steel. A considerable saving is thus effected as compared with the ordinary method of employing pig iron, either cold or molten, as the chief material of steel. So far the Lash mixture has been used mainly in the open hearth furnace, but it is stated that it can be successfully employed in the electric furnace as well.

Electro Metals Company, Limited

Few people are aware of the fact that the manufacture of ferro-silicon in the electric furnace has been carried on at Welland in the Niagara peninsula for the past year and a half

The company operating this plant is organized under the presidency of Mr. R. H. Wolff, of New York City; Vice-President, Mr. R. Turnbull, of St. Catharines, Ont., with Mr. Walter Gaston, of New York City, treasurer and general manager. There are also interested in the company, the Societé-Electrometallurgique Francaise of La Praz, France; Dr. P. Heroult also of La Praz, and one of the largest Canadian power companies of Niagara Falls, Ont.

The company own about 40 acres of land south of the town of Welland, with a frontage of over half a mile on the east side of the Welland canal, within easy communication of the Michigan Central, Grand Trunk, Canadian Pacific and Wabash railways. The present works are situated on the north side of the property next to the plant of The Ontario Iron and Steel Company. The works comprise a large steel and corrugated iron building, containing the electric furnaces, stock rooms, crushing plant, etc., a transformer room with tower for the entrance of the high tension wires built against the main building, a repair shop and a separate building containing the electrode plant, where carbon electrodes are made of first class quality by a new process. The offices, stores and laboratory are contained in one building placed at the entrance to the property.

The plant is operated at present for the manufacture of ferro-silicon, and it is expected to start manufacturing ferro-chrome about the beginning of July 1908. The

[41] See Journal of the Canadian Mining Institute, Vol. X.

company is now engaged in building a 400-h.p. electric furnace on a new principle for the smelting of iron ore. This problem will, it is expected, be thoroughly thrashed out at Welland with the assistance of Dr Heroult, and if the experiment proves successful larger furnaces will be built immediately. The company has other projects in view t be exposed later, which will be of great interest to the electrometallurgical world.

The Electro Metals Company, Limited, was first of all incorporated with the idea of building a large electric furnace for the smelting of iron ores, but some later experience in this work led to a change of view. It was then decided to use the power in the meantime for the making of the ferro-alloys, in the manufacture of which some of the members of the company are experts, and instead of erecting the large furnace for iron ore reduction, a smaller one has been built for experimental purposes. This new furnace, but recently put into operation, is of 400 h.p., and has been constructed on an entirely new principle suggested by the results obtained in Shasta county, California, where Mr. Turnbull conducted a series of experiments on the electric reduction of iron ores in 1906.

This experimental furnace designed for the use of a three-phase current is provided with three electrodes, one corresponding to each phase, which are not embedded in the charge and in fact do not touch it, as the heat is formed by an arc which strikes between the electrodes and the charge. The electrodes are fixed, doing away with the expensive and troublesome regulating apparatus, and also practically eliminating the consumption of electrode, the arc being controlled by special transformers, giving fixed watts, but allowing the volts and amperes to vary as the condition of the furnace may demand. The waste gases can be either used for heating and partial reduction of the charge before it enters the smelting zone, or may be allowed to escape and be collected for other uses. If this furnace proves a success a larger one will immediately be built at Welland with an estimated output of 25 to 30 tons per 24 hours.

The ferro-silicon furnaces of 1,500 to 1,000 h.p. each are four in number, and are constructed after the ordinary type of Heroult furnace. Essentially, they consist of a cylindrical casing of wrought iron about seven feet high, lined with refractory material, a large single electrode hanging vertically into the open top of the furnace. The raw materials are shovelled into the furnace top and packed between the electrode and the refractory lining, the ring of material gradually sinking as its lower end is melted away with the heat formed by the passage of the electric current. The ferro alloy tapped every few hours is allowed to cool in large cakes, then broken up by hammer and packed in small kegs for shipment. From five to eight tons of ferro-silicon are produced daily.

An average analysis of the product is as follows:—

Silicon.	Iron.	Aluminium.	Carbon.	Sulphur.	Phosphorus.
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
55.0	43.0	1.0	0.160	0 040	0.036

The transformer capacity is at present 6,450 h.p., and is made up as follows:—Six transformers of 1,000 h.p. each and three of 150 h.p. each, all made by the Packard Company of St. Catharines. The transformer and furnace rooms are large enough to hold an installation of 10,000 h.p. capacity, and this available space will be utilized in the near future by the addition of new units.

The development and progress of this company and especially its efforts in the line of electric reduction of iron ores will be watched with much interest by every one familiar with metallurgical work, since it is engaged in attempting to solve a problem of vast importance to this Province, and to the world at large.

The writer wishes to thank Mr. Turnbull for information and kindnesses received during his visit to Welland.

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